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OF
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(Supplement)

Studies in Animal Behaviour

Editors :

B. S. RAO & P. S. SHETTY

DEPARTMENT OF PHYSIOLOGY

St. John's Medical College, Bangalore - 560 034

To
Dr. C. M. Francis
With best compliments
From Editors
BS Rao
11.11.84.

STUDIES IN ANIMAL BEHAVIOUR

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FOREWORD

Ethology – the study of animal behaviour from a biological view point – is really a new science although we can reckon its beginning with the work of Charles Darwin. Now a century after Darwin, it has made rapid strides and grown enormously in stature and importance. The term *ethology* is based upon the Greek *ethos*; which can refer to a characteristic disposition or habit that is a distinguishing feature of an individual or group. St. Hilaire chose ethology to refer to the study of animals as living beings in their natural environments; a field now divided between ecologists with relationships and ethologists with behaviour. Ethologists are entrusted with the task of explaining the varied responses of animals to different situations that they encounter. It connotes comparisons among species, as well as physiological, ecological and evolutionary aspects of the subject. The view which underlies modern thinking for an understanding of behaviour differs from the molar-molecular approach in subtle but significant ways. It is felt that there are three separate reasons for causation of behaviour: the selective advantage of function, the phyletic history and the ontogeny of behaviour; and that the mechanisms must be studied in conjunction with the interactions of the organism in order to understand the regulation of behaviour.

Ethologists have an advantage over scientists who study any human behaviour; for instance, they can very often test hypothesis by comparing the behaviour of different species. The use of interspecies comparisons is part of ethology's heritage as a branch of evolutionary biology: they were employed in comparative physiology, comparative anatomy, and systematics before ethology began, and have continued to be useful. As evolutionary biologists, ethologists feel most naturally occurring

behaviours to be adaptive. They contend that the behaviour with which animals respond to their environments function to sustain and protect the individuals and to ensure the perpetuation of the species. Beer (1975) has said aptly that "the best ethological work . . . . has a quality that is emergent from a combination of profound curiosity about, refined perception of, and exquisite feeling for the patterns of behaviour shown by different kinds of animals in nature". It is in this context that this publication which is in your scholarly hands has been prepared with great care and assidous planning. The Ethological Society of India (ESI) was born in 1970 and since then has nurtured its aim and objectives with the active participation of all its members and functionaries. It has held animal conferences at different places under prestigious auspices but the 12th Conference held during May 1983 at St. John's Medical College, Bangalore is unique in more than one sense. For the first time the ESI had the opportunity to hold its meetings in the midst of the noble medical profession emphasizing the unity of behaviour between animals and man. This would not have materialised but for the dedicated effort of the editors, Dr. B. S. Rao and Dr. P. S. Shetty of the Department of Physiology, St. John's Medical College, Bangalore to whom the Society is greatly beholden. Our heartfelt thanks are also due to Dr. G. M. Mascarenhas, the Dean who gave in a good measure encouragement and all help to conduct the Conference and bring out the publication.

Outstanding features of this supplement to the Bulletin include : an understanding of various aspects from biorhythms to feeding; communications to sociobiology; bat to man—all these based on concepts mainly from an evolutionary and neurophysiological basis. The spectra of species covered extend from simple invertebrates to sub-human primates. The volume deserves to be in the hands of ethologists to help create an

awareness regarding the diverse types of work going on in our country and help build an atmosphere conducive for further work. May this be a harbinger for future accomplishment. After all—'nothing succeeds like success.'

M. D. Parthasarathy,
M.Sc., PhD. (Purdue)., F.Z.S. (Lond.)
President,
Ethological Society of India

March 1984

PREFACE

Studies on animal behaviour in natural habitat as well as under laboratory conditions are included in this volume which is based on the Proceedings of the Twelveth Annual Conference of the Ethological Society of India held at St. John's Medical College, Bangalore. Behavioural parameters of the living in aerial, aquatic and terrestrial habitat and of animals ranging from earthwork to sub-human primates are compiled. The bulk of the papers were read at the Twelfth Annual Conference of the Ethological Society of India, but some were received for publication to the Bulletin of the Ethological Society of India (ESI). The twenty six papers have been divided into eight categories based on the main aspect of behaviour reported in the article. We are of the opinion that ethology should not be restricted to mere reporting of behaviour, but be extended to discover the basis of the behaviour and hence a section on mechanisms of behaviour is included. A paper on endangered wild life is also included because of its interesting information content.

We remain grateful to several people who were helpful at one stage or the other in the preparation of the present volume and at times when we were up against major financial hurdles. The credit for initiation of publication of the Proceedings goes to the Executive Committee of the ESI (1983) and in particular to the President of ESI, Dr. M. D. Parthasarathy, who has also written the Foreword. To Dr. G. M. Mascarenhas the Dean of St. John's Medical College, Bangalore, we express our thanks for allowing us not only to host the 12th Annual Conference of ESI but in addition for his moral support to us during the editing and publication of the Proceedings. The Department of Science and Technology, New Delhi were kind enough to help us financially. We are grateful to them. The authors of the papers

have had to bear with delays and our constant demands for early payment; we owe them our thanks in abundance. To Santon Printers, Bangalore, who have done a good job inspite of the many hurdles on the way, and delays on our part our special thanks are due.

We hope that the present volume will be useful to all students of Ethology.

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P. S. Shetty

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Interaction of Biological and Experiential Variables in Development : An Ethological Perspective

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The study of ethology has indeed come a long way since the celebrated triumverate, Karl von Frisch, Konrad Lorenz and Niko Tinbergen shared the nobel prize for physiology and medicine in 1973. Together, they showed how to gain deeper insights into the organization of the nervous system through incisive experimentation in ethology. Two useful approaches have since been sustaining the progress in this field. One deals with the behaviour of the individual organism in terms of its component sensory and motor elements. The edifice of ethology at this level stands on the twin pillars of sensory physiology and integrative neurophysiology. The other approach, which should in fact be viewed as the related logical extension of the first one concerns itself with the study of populations, including sociobiology[4]. As is the fond hope of many workers in this field, some day, man may not only be able to find at least some of the biological roots of his own nature but may even gain a better understanding of what is so unique about the culmination of the invisible but extraordinarily effective evolutionary processes, which affords him such a special place on this planet in terms of his own behavioural capabilities, through the study of Ethology.

No matter whether one is dealing with the individual organism or a group of organisms, the interaction of biological and experiential variables in shaping the behaviour cannot be lost sight of[8]. The apparent conflict that existed till recently between the primacy of maturational processes underlying the development of behaviour and the preponderance of experiences in moulding the behavioural repertoire of the organism(s) has now yielded place to an inevitable synthesis of the two concepts.

No doubt, the maturational forces determine the basic growth function in sensory-perceptual systems, but experience does seem to play a role in the fixation of the resultant behavioural patterns in the time scale of an individual organism's age. I propose to illustrate the phenomena with examples drawn from two relevant areas of research.

Studies on sensory maturation:

Maturation of sensory systems can be studied in terms of structure, electrophysiology as well as behaviour. Ontogenetic sequences can be more easily studied in the visual system as it develops later in ontogeny than the physiology of tactile, olfactory or auditory systems in all mammals studied[24]. Different retinal layers each, with its own characteristic cell types follow a differential growth pattern in rat, post-natally, until the adult-structure is obtained[15]. However, more readily discernible maturational processes can be studied through electroretinography. The electroretinogram (ERG) can be recorded through wick electrodes. While one eye is being stimulated and the electrical response picked up, either on a sensitive pen recorder or an oscilloscope, the other eye must be used for placing the indifferent electrode. This was proved to be the best way to record almost noise free ERG [18,19,20,21]. In rat, the profile of ERG, as is seen in adults with 'a' 'b' and occasionally 'c' (very rarely 'd' wave) cannot be recorded until after it opens its eyes on the 14th day. The attempts to record

the electrical response prior to this age by opening the eyes prior to day 12 yielded only a small 'a' wave with neither 'b' nor 'c' wave. The recording of ERG postnatally on subsequent days clearly showed that the appearance of a prominent 'b' wave, similar to that of adults could not be obtained until after 14th day. The profile of ERG changes in such a manner to bring about an increase in the amplitude of these two dominant components thereafter, and reaches the adult stage on 20th postnatal day[16].

The behavioural experiments carried out to test the development of sensory perceptual mechanisms yielded far more interesting results. Through an experiment performed to observe a 'startle' response (Fig. 1) of the postnatal rat from the day 14, when light is made to incident over one of its eyes, while placed in an otherwise restraining chamber, from which a periscopic viewing tube emerges, enabling the experimenter to observe and record the response of the young rat, it was clear that the lowest intensity (20 lux) to which it can respond through a 'startle' was not effective until after the postnatal day 17.

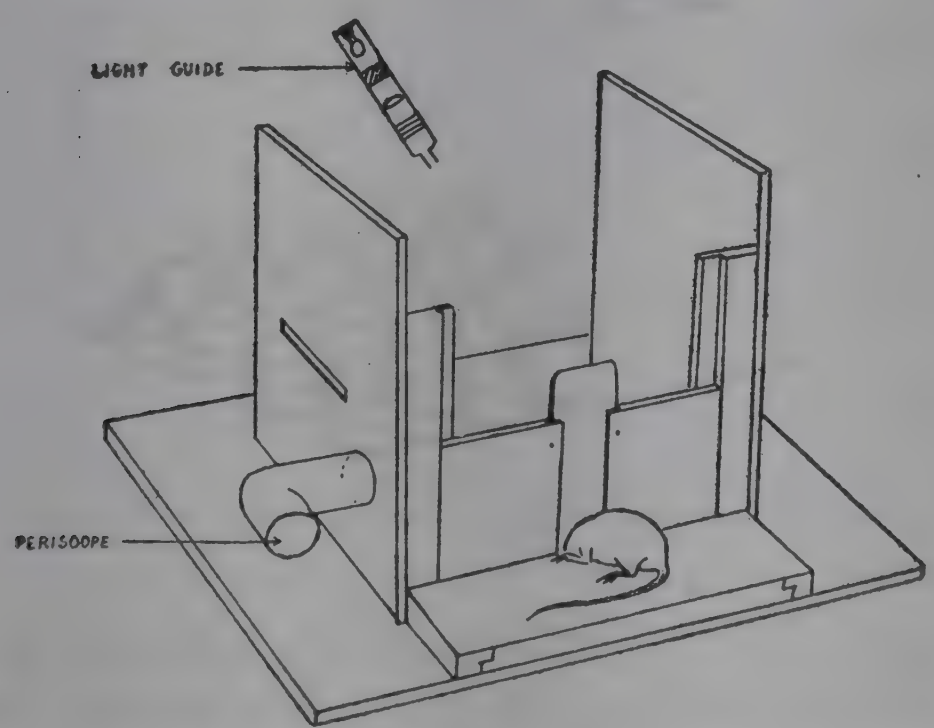

Fig 1. Restraining chamber, which permits the experimenter to observe the 'startle' response of the rat to light-stimulus of varying intensities.

However a different experiment carried out to test the depth perception in a visual cliff apparatus (Fig. 2) clearly showed that the majority of the rats chose the safer, seemingly 'shallow' chamber only on day 18, indicating not only that more complex processes are involved in depth-perception, but they also seem to mature much later than those required for intensity perception[17,23]. The important point to note in all these experiments is that exposure to light after the rat opens its eyes somehow seems to reinforce the maturational processes resulting in an orderly development of the structure, function and the related behaviour. Several reports amply proved particularly in cat, that sensory deprivation induced by suturing both eyelids or by dark rearing during a critical period results both in failure of this rapid maturation and in a breakdown of pre-existing organization[3,25].

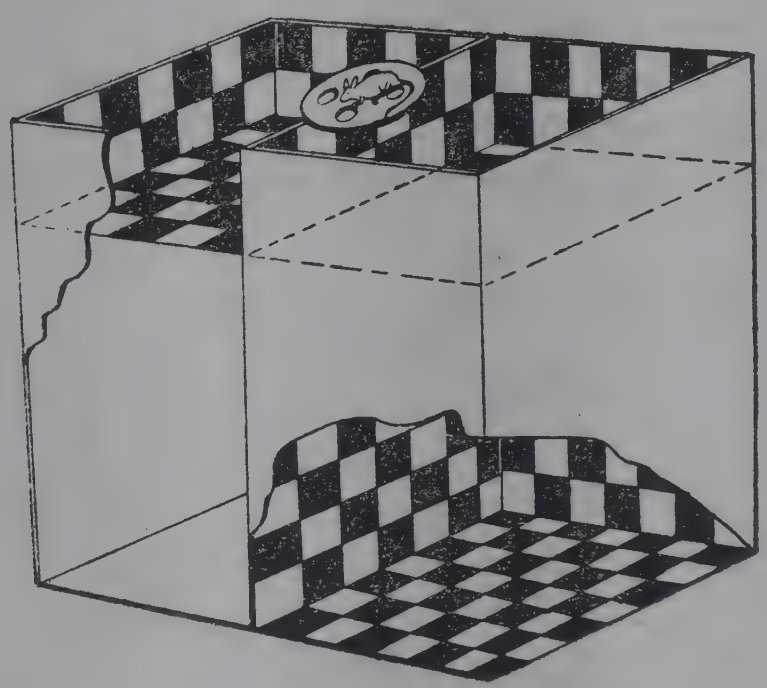

Fig. 2. Visual-cliff apparatus, to test the depth-perception of the post-natal rat

Such an interaction of biological and experiential variables is pronounced and discernible even in psychological systems, that emerge during the first two years, in that the maturational forces propel the growth function of these systems whereas

experience determines the age at which these competences appear, and with what intensity and frequency.

Studies on sexual maturation :

Such interactions are nowhere more pronounced and more effective than in the physiological processes underlying sexual maturation and perhaps the consequent as well as concomitant sexual behaviour. The reports that the girls are attaining the age of menarche much earlier now than a decade or two earlier all over Europe, U.S.A. and in India, provide an interesting analogy [1,6,11,12,26].

Experimental studies using rats and mice clearly established that when reared in the presence of males during prepuberal stage, their sexual maturation is advanced whereas rearing them in isolation of males delays the same.[14,26]. A pheromone, as yet unidentified chemically, in the urine of the male has been proved to be the effective stimulus triggering such advancement [13]. Although, it is difficult to prove conclusively such causative factor(s) for earlier menarche in human population, it is interesting to note that, besides a combination of factors such as better nutrition, higher standards of health and living, the increasing intensity as well as frequency of male - female interaction in the prepuberal population of the present day society must have played a key role in this secular trend towards earlier menarche [12,14].

While the debate regarding the role of limbic brain areas such as amygdala and hippocampus, the role of noradrenergic/ dopaminergic systems, their possible reciprocal influences, in bringing about the pubertal events such as vaginal opening and the first estrus, in experimental animals such as rat continues [13,22]. It is becoming increasingly clear that social interactions and the consequent experience does play a crucial role in fixing the point of maturation in the temporal scale even while the basic

biological factors are at work in completing the necessary structural circuitry.

Relevance to Human behaviour :

The projection of the doctrine of interaction of biological and experiential variables in development to the human behaviour is of exceeding importance. In this context, among several major differences between man and animal such as the language, the opposable thumb, upright stature, an omnivorous diet, sexual behaviour throughout the year, the prolonged infancy seemed to be crucial so that nature can bestow on him a myriad skills, not seen among the animal kingdom through maximal plasticity and malleability to training during this prolonged period of infant helplessness. Although, John Fiske's idea [5] of strong continuity from the period of infancy to latter childhood propounded in 1883 is no longer tenable in its original form, what, undoubtedly stood the test of time is the premise that if there is continuity of dispositions from infancy to adolescence, it is likely to appear under conditions where the environment has a reinforcing effect on those particular qualities. For example, a disposition such as babbling of a 4 month old baby is not only biologically variable but also modifiable by environment. Kagan [7] had shown that a highly vocal 4 month old, born to lower or working class parents who generally do not encourage early vocalization was not any more talkative than a non vocal infant. What is even more remarkable is that maladaptive dispositions can be outgrown, given the environmental opportunity, while the adaptive characteristics are more likely to be retained. Macfarlane [9,10] reported that many children who showed pathology, lost it as they found better environmental niches. Thus the infant's qualities are continually adapting to environmental pressures.

Conclusion:

It has been amply proved through elegant experiments involving individual organisms in the laboratory as well as through classical studies in ethology of animal and human populations, that the interaction of biological and experiential variables determines the development of behaviour and the growth of structural substrates underlying it. The new trend in child development is strengthening our belief in the old maxim that experience and biology interact in producing individual growth patterns.

Acknowledgment:

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In search of an index of aggressive dominance in laboratory rats

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The study of aggression in animals has been one of the foremost concerns of ethologists. Several decades of empirical studies and theoretical dialogues have lead to a change in the concept of aggression from 'aggression as an instinct' [5] to aggression as it is expressed in a social context [11]. In laboratory rats, which have been removed from their natural environment for generations, the study and measurement of aggression should be restricted to artificial social situations.

In has been demonstrated, both in the field [9] and the laboratory [6], that the dominance of an animal over other(s) is determined by the aggressiveness of the animal. In laboratory rodents a technique called 'limited access' was introduced by Bruce [3] to measure the competitive dominance. In such studies the animals are deprived of food or water and are, then, made to compete for access to a resource available only to one animal at a time. The technique has been used by a number of researchers [1,2,4,7,8]. The measures used as indicators of competitive dominance were the time spent at the source during competition [1] or the amount of food consumed [4].

Syme et al [10] recorded the 'time spent' and 'weight gain' of an animal in three conditions: Normal, Non-competitive social and Competitive. They did not find any significant differ-

ence in these measures during different conditions, and concluded that dominance in rats could not be measured in the limited access situation. One implication of the findings of Syme and his associates [10] is that the dominance orders obtained from a competitive situation could be the same as from a non-competitive situation, since in competitive situation an animal eats, and gets to eat, according to its requirements. If this argument is valid, a further implication of it would be that the animal with higher motivation should consume more food, and spend more time at the source, during competition, than the animal with a low motivation. The purpose of the present study was to investigate the above implication of Syme's argument, as well as to find a genuine index of aggressive dominance in rats.

Materials and Methods

The studies were conducted on 52 male and 54 female, albino rats. Three tests were carried out to measure the competitive dominance. The animals were from a stock with homogenous housing and rearing conditions. In each of the tests, the animals were deprived of food/water for 48 hours. They were then made to compete with each other for access to food/water. The competition tests were conducted in a separate test cage where the food/water hole was accessible to a single rat at a time. To minimize the exploratory activity, each animal was made familiar with the test cage for several days prior to the testing. To avoid the formation of dominance hierarchies, the pairs and groups of animals were formed in such a way that one rat never met any other rat more than once in all the tests. During contest for food powdered wet food was supplied to avoid hoarding by an animal. The schedule of successive tests is given in Table 1.

Table 1. *The schedule of tests*

Deprivation period	Deprivation of	Nature of test	Duration of test	Normal feeding after test
48 hours	Food	Pairwise	15 min	48 hours
48 hours	Food	Group of 4	15 min	48 hours
48 hours	Water	Group of 4	10 min	Normal feeding

The observations were made on the following variables :

a. Body weight before and after deprivation.
b. Weight loss due to 48 hours deprivation.
c. Absolute gain and present gain in body weight after eating/drinking during the contest period.
d. Time spent–the possession time of the food/water cup during the contest period.
e. Successful and unsuccessful attempts at displacing other animal from the source during contest.

For the purpose of final calculations, the values taken were the means of all three tests for each variable. Product–moment correlations were calculated among the various measures and variables.

Results

The first set of correlations is shown in Table 2.

Table 2. *Correlations*

Measure 1	Measure 2	r		Significance	
		M*	F*	M	F
Weight loss	Time spent	0.16	0.14	NS	NS
Weight loss	Absolute gain	0.06	0.13	NS	NS
Base weight	Time spent	-0.18	–0.26	NS	NS
Base weight	Absolute gain	-0.21	0.01	NS	NS
Base weight	Percent gain	-0.30	-0.44	.05	.01
Weight before test	Time spent	-0.20	-0.29	NS	.05
Weight before test	Absolute gain	-0.22	-0.02	NS	NS
Weight before test	Percent gain	-0.32	-0.44	.05	.01
Time spent	Percent gain	0.38	0.46	.01	.01
Time spent	Absolute gain	0.34	0.38	.05	.01

M – Male
F – Females
N = 52 each
NS = Nonsignificant

One remarkable finding was the similarity in the nature of correlations for both sexes providing high consistency and reliability of the measurements. The correlations between 'weight loss' and 'time spent' and 'weight loss' and' absolute gain' (males 0.16, females 0.14 and males 0.06, females 0.13 respectively) were nonsignificant.

Similar nonsignificant correlations were also obtained between 'base weight' (weight before deprivation) and 'time spent' (males–0.18, females–0.26) and between 'base weight' and 'absolute gain' (males–0.21, females-0.01). The correlations were also computed betwen the measures of dominance and body weight just before testing (after deprivation). All correlations were once again nonsignificant, except one for females between 'weight before test' and 'time spent' (r-0.29) which was a negative correlation. The correlations between 'percent gain' and other measures showed the same trend as the relationship of absolute gain with other measures except that the correlation between 'percent gain' and body weight was negative and significant. The 'time spent' and the 'absolute gain' which were taken as measures of dominance yielded a significant positive correlation both for males and females (0.34 and 0.38 respectively).

The other measures of dominance taken were the successful and unsuccessful attempts. The correlations between these attempts and other measures are shown in Table 3.

Table 3. *Correlations*

Measure 1	Measure 2	r	Significance
Successful attempts	Absolute gain	0.18	NS
Unsuccessful attempts	Absolute gain	0.20	NS
Successful attempts	Weight before test	0.20	NS
Unsuccessful attempts	Weight before test	0.23	NS
Successful attempts	Unsuccessful attempts	0.30	.05

NS = Nonsignificant n = 54

Successful and unsuccessful attempts were found to be nonsignificantly correlated with the absolute gain as well as the body weight before testing. The successful and unsuccessful attempts, however, were themselves significantly ($P < .05$) correlated (r 0.30).

Discussion

In the present investigation, two conventional, and one rarely employed, measures were taken as indices of competitive dominance in a limited access situation. The first measure was the time spent at food/water source which was accessible to only one animal at a time. Since the animals were deprived of food water for 48 hours and they were tested either in pairs or in groups of 4, they would struggle with each other for access. The difference among individuals in time possession of the source, then, would also indicate their dominant and subordinate characteristics. This measure has been extensively used earlier [1,10].

The second measure was the absolute, and also the percent, gain in body weight after eating/drinking during the test. Since the albino rats react very sensitively to food by fluctuations in their body weight, the gain in body weight would give a comparative indication of the amount of food/water ingested by the animal [4,10]. The third measure taken was the successful and the unsuccessful attempts to gain access to the source by displacing the other competing animals already there.

The purpose of the present investigation was two-fold :

(a) If the correlations between weight loss due to deprivation and weight gain after test, or between loss and time spent at source during contest, were significantly positive, the argument of Syme et al [10] that these two measures do not indicate dominance would

be further strengthened, because the positive correlations would only mean that the amount of time spent and weight gain are determined by the intensity of hunger.

(b) If these correlations were nonsignificant, then these two measures should be correlated with other variables to establish their reliability as an index of aggressive dominance.

Due to a long deprivation of food or water like that of 48 hours, the rats lose their body weight considerably. It is possible that during competition situations, the animal who has lost relatively more body weight would also eat more because the hungrier the animal the more food it will consume. The present correlations between absolute gain and weight loss on one hand, and the time spent and weight loss on the other, were nonsignificant, both in case of males and females. This observation clearly indicated that the absolute gain in body weight due to eating/drinking, and the time spent at the source during the contest period were not a function of the motivational state of the animal. The argument of Syme et al.[10], therefore, seems doubtful that the eating/drinking during contest period is based only on the requirement of an animal.

In organisms like albino rats, the body weight is generally taken as a reliable measure of the physical strength of the animal. The results of the present study showed that the body weight (both before deprivation and prior to the test) had no relationship either with the time spent at the source during the contest or with the absolute gain in body weight after the test. This was true for both sexes. This observation indicated that the two measures of aggressive dominance taken in this study were not a function of the physical strength of the animal. The percent gain in weight after the test was however significantly negatively correlated with the body weight. Although non-

significant, the correlation between absolute gain in body weight and the base weight was also negative.

Though during the contest, only one animal at a time could reach the source of food or water, it was observed that sometimes some animals who were relatively smaller in size could squeeze in to share the resource. This observation is made more reliable by the fact that the value of negative correlations between percent gain and body weight is smaller in the case of males. Because the males generally tend to be larger than the females they, therefore, could not squeeze in as easily as the females could. The significant negative correlation between the percent gain and body weight cancels the possibility of percent gain to be a measure of aggressive dominance. Furthermore, since weight gain and time spent have shown no relationship with physical strength, there is no logical reason for percent gain to be considered at all.

As mentioned earlier, the successful and the unsuccessful attempts to gain access to the resource by displacing other could also serve as indicators of aggressive dominance of the animal in a competition situation. In the present study, however, the correlations between both successful as well as unsuccessful attempts and body weight as well as gain in the body weight after the test were all nonsignificant. Surprisingly the successful and unsuccessful attempts were themselves significantly positively correlated. If successful attempts could be a measure of aggressive dominance, the relationship between successful and unsuccessful attempts must be significantly negative. The observation in the present study therefore cancels the possibility of this measure to be an index of dominance.

The results of the investigation and the discussion made so far lead to the conclusion that the absolute gain in body weight by eating/drinking, and the time spent at the source, during the

contest could be taken as relatively reliable measures of aggressive dominance in competition situations like the ones designed in the present investigation.

In the case of both sexes, the time spent and the absolute weight gain were significantly positively correlated. This observation provides a logical base for combining these two measures. It can be done by converting the time spent into absolute gain. A constant can be reached at by dividing the mean time spent by all animals with the mean absolute gain in body weight. The time spent by each animal then can be divided by this constant and added to the absolute gain in weight to reach a single value. This value can serve as an index of aggressive dominance.

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Behaviour of Feral Cattle, Bos indicus, in the Grazing System of District Chhatarpur

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Although feral cattle *Bos indicus* were known since the 19th century [17], neither behavioural studies nor fresh reports of their existence are available [2,6,8,14,16]. In some areas of Chhatparpur district (M.P.), nocturnal destruction of rabi crop by herds of such cattle has lead to catching under the Central Government's wild cattle catching scheme. Besides agricultural importance, their total dependence upon over-exploited grazing lands and the associated mode of crop destruction underline their ethological and ecological significance. Considering the importance of food availability on the grazing behaviour of cattle [7,12,15], the present investigation is an attempt to analyse destructive behaviour of feral cattle.

Materials and Methods:

Contribution of the grazing system in the diet of *B. indicus* was determined monthly during an annual cycle. Since the females of domestic species have a grazing system common with that of the feral cattle of different states, domestic female animals alone were chosen in triplicates. The same cows were taken for every month's observation.

The rate of biomass removal from grazing system/animal and the diet/animal were determined monthly and trimonthly respectively. For the first determination, the selected cows were left in the morning without stall feeding for grazing. In the evening, the animals returning from the grazing system were brought directly to the experimental site for stall feeding in open. The weighed amount of feed, freshly prepared by adequate moistening of wheat husk with 15% barley flour and sampled for determination of its moisture content, was offered in containers separately until the animals declined to eat anymore. The feed left by each animal was weighed and again sampled for moisture content. When the milk yielding cows were given extra feed by its owner in the morning or evening it was noted and kept constant during the days of diet determination. In case of feeding experiments involving the diet determination, the animals were kept at the experimental site for further 48 hours. Preparation of feed and feeding were done twice a day. Due care was taken to avoid grazing or unrecorded feeding of animals during these hours. The intake observations were converted to their oven-dried values (at 80°C for 48 hours) before computations.

Computations :

Let

Fo = Wt. of feed offered to the animal in the container.

Fl = Wt. of feed left by the animal in the container (after reaching the satiation).

Fu = Wt. of unavoidable feed/animal/day (given by the owner of the animal).

Fe = Wt. of feed eaten/animal/feeding.

Fd = Total Wt. of feed eaten in two feedings of a day by an animal.

b = Wt. of biomass removed/day by an animal from the grazing system.

Dt = diet of animal/day

Ct = Contribution (% of Dt) of the grazing system/animal/day.

Then

$$Fe = Fo - Fl$$

$$Fd = Fe \text{ of morning} + Fe \text{ of evening}$$

$$Dt = \left\{ \frac{Fd \text{ of second day} + Fd \text{ of third day.}}{2} \right\} + Fu$$

$$Ct = \frac{b}{Dt} X\ 100$$

Results And Discussion :

Contribution of the grazing system to feeding declined twice in the year i. e. in winter and summer (Table) and the winter decline coincided with the rabi crop. The destruction of rabi crop by feral *B. indicus* seems to be a hunger–generated-compulsion as indicated by the need for supplementary feeds in the domestic forms during this period. The increase observed in the search movement of cattle [12] as the winter season progressed futher supports the same hunger-generated-compulsion. The rabi crop which is the most preferred crop in the area suffers severe damage while the kharif crop remains fairly undisturbed. The availability of crop residues and grass in the harvested fields and the fruits of *Madhuca indica* probably caused a rise in contribution of grazing system in April. The increase shown in March, when the crop was standing, may be due to periodic foraging into rabi crop fields by experimental animals inspite of the herdsman's control. The wild gaurs, *B. gaurus*, raiding the crop in some parts of the range have also been reported [8]. Thus, it is clear that the crop is destroyed by feral *B. indicus* being driven by hunger compulsion. However, a detailed and comparative field study of grazing behaviour of feral and domestic *B. indicus* will obviously contribute to a better behavioural analysis.

The recorded observations show the grazing system is not sufficient to support the existing cattle population in winter and summer. The feral cattles' removal is neither expected to

TABLE

CONTRIBUTION OF THE GRAZING SYSTEM IN THE DIET OF *B. indicus* DURING 1982–83.

	Month	State of the animal	Time spent/ day in the system (in hours)	Diet of animal/ day (average, in kg.)	Biomass removed from the system by animal/day (average, in kg.)	Contribution of the system/ animal (% of diet).
1.	February	herdsman's control	9.05	2.873 ± 1.462	1.287 ± 0.675	44.8
2.	March	,,	10.20	3.074 ± 1.428	1.926 ± 0.833	62.7
3.	April	Free	13.00	3.959 ± 1.677	2.990 ± 1.054	75.5
4.	May	,,	12.00	3.856 ± 1.733	1.636 ± 0.582	42.4
5.	June	,,	12.00	3.527 ± 1.684	1.190 ± 0.297	33.7
6.	August	,,	12.00	3.276 ± 1.604	2.275 ± 0.692	69.4
7.	September	herdsman's control	11.30	3.165 ± 1.261	3.056 ± 1.115	96.6
8.	October *	,,	14.00	3.165 ± 1.261	2.668 ± 0.879	84.3
9.	November	,,	9.20	3.122 ± 1.039	1.532 ± 0.430	49.1
10.	January	,,	8.50	3.122 ± 1.039	1.436 ± 0.390	46.0

* Time spent in the system in October includes the hours of night grazing.

improve the system nor will provide any long term agricultural gain. Their adjustment in an unfriendly habitat without supplementary diet, especially in summer, is of ethological and ecological significance [1,3,4,5,9,11,13]. As wild ***B. indicus*** is the only wild relative of domestic *B. indicus*, its behaviour as compared to the latter may pay rich agricultural dividends. There is an urgent need to withhold noose-catching which is a mere treatment of the symptom rather than the disease, unless the entire matter is properly weighed.

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Effects of Intake-Time Restrictions on Behavioural Intake

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Meal-time restriction causes a reduction in daily food intake in spite of "gorging" during meal-time [1]. The gorging leads to increased deposition of fat [2]. Because of abnormally increased fat storage in their body, the body weight of meal-time restricted rats becomes similar to the body weight of adlib fed animals though food intake is less [1]. Thus maintenance of body weight of meal-time rats deviates from Collier's hypothesis [3] that food intake determines body weight, (log intake/log body weight). However it is also known that apparent increase in the body weight of semistarved persons is caused by edema [4]. It gave rise to a doubt whether body weight increment in meal-time rats was also due to accumulation of water in their tissues. The present investigation is therefore initiated to estimate the tissue water content of meal-time rats. In order to account for changes if any, in tissue water content the oral intake of water and urine output are also investigated.

Methods and Materials

Adult male rats housed in individual cages and fed adlib for 10 days are used. They were divided into three groups with six animals in each group. One group (Gr I) was continued on adlibitum feeding and served as controls. For the second (Gr II) food was available for 3 hr period (9 am – 12 noon) whereas water was available 24 hrs. The third group (Gr III)

had both food and water for 3 hr period (9 am - 12 noon) only. Every day between 8 am - 9 am body weight and urine output of all rats were measured. In addition 24 hr food and water intake of Gr I rats and 24 hr water intake of Gr II rats were measured. Fresh food and water were given at 9 am. At 12 noon, food and water intake of all rats were measured. Further, food cups of Gr II rats, food cups and water bottles of Gr III rats were removed at 12 noon. After 140 days of adaptation to respective feeding regimens the body weights of all groups of rats were almost similar. Then they were all sacrified by decapitation. The heart, liver and gastrocnemius muscle from each animal were isolated, and their wet weights taken immediately. The tissues were dried for 2 days in hot air oven at 80°C, and then the dry weight was taken. From the difference between wet and dry weight, tissue water percent was computed.

The intake and urine output are computed as mean $\pm$ sem per 100 gm body weight. The Students' 't' test is used for statistical analysis and $P<0.05$ is taken as a significant difference.

Results

The patterns of food intake and body weight changes of Gr I, Gr II and Gr III rats were almost similar to the patterns shown by meal-time rats reported by us earlier [1]. The tissue water content of G II and Gr III rats was similar to tissue water content of Gr I (Table 1). Gorging in Gr II and Gr III was evidenced by their increased food intake in 3 hr meal-time over 3 hr food intake of Gr I. How ever, Gr II and Gr III daily food intake which is the same as that consumed in 3 hr meal-time was less than the daily food intake of Gr I. The water intake in general was proportional to food intake as indicated by constancy of 24 hr water/food ratio at about 1.2 excepting for 3 hr water/food ratio of Gr II and Gr III which were reduced. The urine output of both Gr II and Gr III rats showed tremendous decrease as compared to Gr I urine output. The decrease in Gr III rats urine output was roughly proportional to decrease in their water intake. In con-

Table 1. EFFECTS OF INTAKE–TIME RESTRICTIONS ON FOOD AND WATER INTAKE AND URINE OUTPUT AND TISSUE WATER PERCENT OF RATS

per 100 gms. b. w.	Adlib (Group I) 3 hr	Adlib (Group I) 24 hr	Meal-Time Restriction (Group II) 3 hr	Meal-Time Restriction (Group II) 24 hr	Meal-Water Time Restriction (Group III) 3 hr	Meal-Water Time Restriction (Group III) 24 hr
1. Food intake (gm)	1.8 ± 0.06	10.7 ± 0.52	9.6 ± 0.17	—	6.1 ± 0.58	—
2. Water intake (ml)	2.2 ± 0.15	11.2 ± 0.41	4.5 ± 0.14	11.4 ± 0.42	5.2* ± 0.17	—
3. Water/Food	1.2 ± 0.08	1.1 ± 0.04	0.5 ± 0.09	1.2 ± 0.05	0.8 ± 0.03	—
4. Urine output (ml)	—	2.6 ± 0.35	—	0.9 ± 0.13	—	0.3 ± 0.04
5. Tissue water %						
a. Liver	70.3 ± 0.25		69.8 ± 0.68		70.1 ± 0.31	
b. Heart	77.5 ± 031		76.8 ± 0.36		75.5 ± 0.83	
c. Gastrocnemius	70.8 ± 0.23		702 ± 0.69		71.2 ± 0.42	

mean ± sem

b.w. = body weight

trast Gr II rats showed decrease in urine output despite normal 24 hr water intake.

Discussion

The similarity of tissue water content of Gr II (meal-time restricted), Gr III (meal-water time restricted) and of Gr I (free feeding rats) indicates that increase in body weight of time-restricted rats on low food-intake is not due to accumulation of water in their tissues. However the interesting aspect of this study is the appropriate alterations shown by time-restricted rats in behavioural intake of food and water as well as urine output to preserve tissue water content. In spite of "stuffing" their stomachs, they managed to maintain the well known constancy of water/food ratio[5]. It appears that tissue water constancy of Gr II and Gr III rats was achieved via preservation of constancy of their water/food ratio as no factor other than solid food intake was involved in disturbing homeostasis of tissue water content. Hence the manner in which Gr II and Gr III rats maintained constancy of water/food ratio is important. Behavioural responses of Gr III rats in this regard serves as good example. The oral water intake of Gr III rats was less than that normally required by its food intake as indicated by reduced water/food ratio (0.8 ± 0.03). Their renally reabsorbed water (difference between urine output of Gr I and Gr III which is 2.3 ml approximately) compensated for decreased oral intake of water. The total water intake which is (7.5 ml) the sum of reabsorbed water (2.3 ml) and oral intake (5.2 ml) bears a normal ratio (1.2) to Gr III food intake (6.1 gm). But Gr II rats oral water intake behaviour and urine output were not that clearly adjusted to preserve water/food ratio. Though Gr II rats showed renal reabsorption of water; a decrease by similar amount in 24 hr oral water intake was not shown, and it may be noted that the 24 hr water intake was proportional to their food intake. The renally retained water (1.7 ml, computed as difference of urine output of Gr I and Gr II) which is an extra amount of water was not found in tissues. It gave rise to two questions. The first question is, why was the

water reabsorbed renally in Gr II when 24 hr oral intake was sufficient to meet the thirst caused by food intake? The Gr II renal retention of water was probably due to increased secretion of anti-diuretic hormone (ADH) which in its turn may be a reponse to plasma hyperosmolarity[6] resulting from "gorging" during meal-time as indicated by decreased 3 hr water/food ratio of 0.5. The implication is that thirst was selectively suppressed during meal-time but not the ADH release though thirst and ADH release are both known to be triggered by plasma hyperosmolarity[6]. Earlier evidences that thirst and ADH release may be independent of each other are available[7]. Thirst was low priority information for Gr II rats during 3 hr meal-time as compared to the urgency of eating, because for them water was available beyond 3 hr meal-time. Hence water intake was suppressed during 3 hr feeding time. Such suppressions of low priority informations are documented by early investigators [8,9]. The second question as to why Gr II total water intake (oral intake plus renally reabsorbed amount) was higher than that necessitated by food intake and what happened to that extra amount of water is difficult to answer. It may be that extra amount of water was a consequence of anticipatory neuro-endocrinal response[10] to thirst during the next meal-time and as the amount of water was small (1.7 ml in 100 gm body weight) its measurement in the samples of tissues taken was not possible though tissue weight was accurate to 0.001 gm.

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Food Preferences and Feeding Behaviour of Nilgiri Langur, Presbytis Johnii

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Nilgiri Langur, *Presbytis johnii*, is a colobine monkey confined mainly to the southern half of the Western Ghats. The habitat of the Nilgiri Langur ranges from evergreen forests to moist deciduous forests. Subsequent to the extensive habitat degradation, its population has been considerably curtailed. Unfortunately no systematic investigation on diverse aspects of the ecological requirements and ethology of Nilgiri Langur has yet been undertaken in its natural habitat. Hence this study has been undertaken to elaborate some aspects of the ecology and social organization in the natural habitat of this animal.

The present study was conducted on two troops of Nilgiri Langur in Periyar Tiger Reserve, Thekkady. The Reserve which lies in the Idukki District of Kerala has about 305 km^2 of ever green and 275 km^2 of semi-evergreen forests. 174 troops of Nilgiri Langur had been recorded in the Sanctuary.

Material and Methods:

The data was collected by direct observational means using 10 x 25 Binoculars. The identification of the troop was done mainly from their location in the forest, troop size and

composition and by individual identification. The field work was divided into many parts; twenty days in August 1981, nine days in January 1982, twelve days in September 1982, ten days in November 1982, thirteen days in December 1982 and twelve days in January 1983.

Results and Discussion:

Foliage constituted the major observed diet of Nilgiri Langur in the study area. The main items of food are mentioned below:

NAME OF THE PLANT	PARTS CONSUMED
Thespesia populnea	Young Leaves
Hydnocarpus laurifolia	Seeds
Tectona grandis	Petioles
Ficus sps.	Petioles and Fruits
Acasia intsia	Leaves
Artocarpus integrifolia	Young Fruits
Artocarpus hirsuta	Fruits and seeds
Loranthus elasticus	Fruits and Leaves
Lantana camara	Fruits
Elettaria cardamomum	Ripened Fruits
Cinnamomum malabartrum (= C. zeylanicum)	Leaves
Philodendron sps.	Leaves
Albizzia lebbek	Leaves
Actinodaphne madaraspatana	Leaf tips

Food selection by the Nilgiri Langur troop was examined using data from scan samples made on the study troop between August 1981 and January 1983. These samples were taken from 76 full day observation periods (912 h. total). Young foliage was almost always selected in preference to mature leaves when both were present on the same tree. The same conclusion was made by Oates et.al (1980). Food preferences were in the order of Young Leaves > Fruits > Petioles > Mature Leaves > Flowers > Leaf tips > Leaf Nodules > Young

Table 1 Showing Major Food Items in Nos./Quantity and Percentage of Consumption

Name of the Plant	Leader Male			Sub Adults			Juveniles			Infants		
	Parts Conmd.	No.	%	Parts Conmd.	No.	%	Parts Conmd.	No.	%	Parts Conmd.	No.	%
Schleichera trijuga Willd.	Seeds	48	100	Seeds (exocarp discarded)	33	100	Seeds	30	100	Seeds	13	50
	Buds	39	90	Buds	52	90	Buds	32	90	Buds	8	50
	Young leaves	6	30	—	—	—	Y.L.	2	25	—	—	—
Actinodaphne madaraspatana	Y. L.	26	50	Y. L.	18	50	Y. L.	18	50	Y. L.	6	25
Cinnamomum sps.	M. L.	5	50	M. L.	2	50	M. L.	3	30	—	—	—
Evodia lunuankanda	Y. L.	28	75	Y. L.	23	75	Y. L.	26	75	Y. L.	3	40
Albizzia lebbek	Leaves	78	100	Leaves	72	100	Leaves	60	100	Leaves	9	75
Ficus religiosa	Petioles	177	100	Petioles	206	100	Petioles	142	100	Petioles	7	50
Bark & Insects (Insect Larvae & Pupae)	—	—	15g.	—	—	10	—	—	2g.	—	—	—

Y.L. = Young Leaves M.L. = Mature Leaves

shoots > Bark > Insect Larvae and Pupae. Hand picking, plucking and nibbling were the major modes of adult feeding. The infants, apart from being suckled by their mothers also nibble tender parts of trees.

The Langur turns around the food materials such as tender shoots, leaves and seeds, over and again with the fingers and sniffs at it frequently. Though this behaviour is generally prevalent in all the age groups, the infants and juveniles exhibit this in greater intensity. Nevertheless, when feeding from the same tree is continued for a longer period, the intensity of feeding increases; these behavioural traits of examining and sniffing diminish in frequency and eventually it completely disappears. However, when the animal changes the tree and resumes afresh in another tree the manipulations are initiated again. The food materials are ingested only after chewing them thoroughly. Since the animals do not possess any cheek pouches, the food materials are not stored in mouths As the food is being chewed, the animal starts plucking out fresh food materials and manipulating them with the hands. Soon after the chewed food is swallowed, the fresh food items in the hand are transferred into the mouth. While the mothers feed, the infants often tend to snatch off the food from the mother. Soon after getting the food materials, the infants anxiously scrutinize them by turning them around several times in the hands and by sniffing them frequently. However, instead of ingesting them, the infants generally waste more food by tearing them away.

Feeding Rhythm: During these periods of study it was found that the peak periods of feeding during a day were 7.00–9.00 hrs, 11.00–12.00 hrs. and 15.30 to 17.30 hrs.

Intensity of feeding during different hours of a day is as follows :

Commencing Time	Intensity of feeding
7.00	+ + + + +
8.00	+ + + + +
9.00	+ +
10.00	+ +
11.00	+ + + + +
12.00	+ + +
13.00	
14.00	+ +
15.00	+ + + +
16.00	+ + + +
17.00	+ + + +
18.00	+

In the above table the number of '+' indicates the intensity in feeding. One '+' equals 10 minutes.

Nilgiri Langurs forage among the branches of small trees during the morning and evening hours. During the forenoon period they could be seen on top branches but when it becomes hot they tend to gradually descend and settle down on lower branches.

It was noticed that no food preferences occur among Nilgiri Langurs, based on different age groups. Almost all the members except the infants consumed the same type of food materials during the same period. The infants prefer their mother's milk to any other food items.

A continuous record of the activities of any single animal could not usually be maintained for more than a few minutes because of poor visibility in the dense canopy. Hence observations were mainly carried out on individuals of the same age group rather than any particular individual of an age group.

Observations were made on each age group for three consecutive days and that was repeated four times a year during different seasons. Further the total number/quantity of all types of food items taken by the particular age group was noticed. The quantum of food consumed was also noticed. Equal number of the same material or same quantity as it consumed, was collected and its weight was taken using a single pan balance. The species and part of the plant being eaten were noted, sometimes with a description of the size and colour of the food. It was found that this animal included large quantities of foliage in its diet. The above cited was one of the best methods which can be deployed in assessing the rate of food consumption in the field and hence the data obtained was taken as the nearest to accuracy. From an average of the data obtained during August 1981, January, February, July and September 1982, the daily intake of food by different age groups has been determined. (Table 2)

It was observed that the troop members remained on highest branches during the morning and evening hours and as the temperature increased they descended down to the middle and lower branches. Further it has been observed that mothers with infants always prefer middle branches of the trees. This could probably be for safer foraging.

During the study period, the areas used by the troops were plotted directly on to prepared maps of the study area. It was noticed that the approximate range of each troop was about 2 – 3 sq. kms. The group tended to occupy limited areas of forest for long periods each day, making cohesive movements between these areas. Due to the relatively small size and cohesion of the troop, the occupied areas could be described quite easily on the map. It has also been noticed that based on the availability of food materials the home ranges showed slight changes in both the troops during various seasons.

Table 2: Showing the Daily Intake of Food by Different Age Groups

Parts Consumed	Leader Male		Sub Adults		Juveniles		Infants	
	No.	Wt.(gms.)	No.	Wt.(gms.)	No.	Wt.(gms.)	No.	Wt.(gms.)
Compound Leaves	78	35	72	33	60	30	11	6
Leaves	206	96	231	99	151	66	23	9
Petioles	177	46	206	58	142	30	7	2
Leaf tips	180	22	196	24	130	17	95	12
Buds	28	20	24	18	20	16	11	4
Tender Shoots	8	32	13	48	5	20	2	8
Seeds & Fruits	13 + 6	44	12 + 6	42	6 + 2	5	6 + 1	4
Bark & Insects (Insect Larvae & Pupae)		15	——	10	——	2	——	——
Total Wt.(gms.)		310		332		186		45

The faecal pellets are voided as ball like droppings and as they reach the ground they tend to become flattened. They are generally greenish yellow in colour with a foul smell. One could observe undigested seeds and fibres of both leaves and shoots therein as the major components. Usually an adult animal makes three droppings at a time, each with a diameter of 0.5" to 1.0". It has been noticed that an adult animal defaecates four to six times during day hours. Urine output generally measures 3 to 5 ml. for each discharge. It is a colourless fluid with a pungent odour. Usually an adult animal urinates 4 to 6 times during day hours. (Data obtained during January and April 1983).

Nilgiri Langur is predominantly a foliage feeder exhibiting a specific preference for young foliage, seeds, buds and fruits in contrast to mature foliage which was always available in very much larger quantities in the forests. It also exhibits specific feeding rhythm in correlation to environmental temperature.

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The Snapping Behavior of the Pistol Shrimp Alapheus Malabaricus

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Pistol shrimps belonging to the family alpheidae possess one enormous chela of the first leg [7]. The sudden closure of this chela results in a loud audible sound snap accompanied by emission of water jet. Snapping is shown to be part of defensive and aggressive behavior of pistol shrimps [2,3,6] and useful in feeding. It is not known whether substratum and environmental parameters may influence snapping behavior and hence the present study was initiated.

Material Methods:

The pistol shrimps *Alpheus malabaricus* used in the present study were collected from mud flats of Portonovo waters. The size of the shrimps varied from 27 mm to 36 mm and they were kept in fibre glass bowls (25 cm diam x 9.5 cm deep). To study substrate selection, mud and sand were provided, in addition to estuarine water. The temperature during the experiments fluctuated from 26°C to 30°C and the observations were recorded one hour in day and night.

Six encounter categories were formed for the pairings differing in size and sex of the groups following Schein's method.[7]

D = Day, N = Night, M = Male, F = Female.

I M D : Both shrimp equal size 27mm – 27 mm
II M D : ratio 27 mm — 30 mm
III M D : ratio 30 mm — 33 mm
IV M D : ratio 33 mm — 36 mm
V F D : ratio 27 mm – 30 mm
VI M N : ratio 27 mm — 30 mm.

Chi–square test analysis was applied to test the relationship between different factors studied.

Results and Discussion

The present study revealed that snapping frequency was higher in mud substratum than sand and estuarine water (Table 1.). Mud substratum contains a high proportion of organic matter resulting in more faunal density [1,2,5] and that may be the reason for increasing number of snaps. Further the texture of mud substratum allows free movements of the pistol shrimps which may be helpful in escaping from predators in addition to catching the prey.

Table 1 : Effects of medium and day–night changes on snapping of Alpheus malabaricus

Encounter	I to IV M	V F D	VI M N
Medium	Day		Night
	Snapping frequency		Snapping frequency
Water	6.2		5.0
Mud	11 2		10.0
Sand	5.0		4.0

$\bar{x}^2 = 0.14 < 5.991$

Observations on effect of temperature indicated that snapping frequency was minimum at 26°C and maximum at 29°C., (Table 2). A further increase in temperature resulted in decrease of snapping behavior thus showing that optimum temperature for snapping behavior is 29°C as in other arthropods,[4] probably because at that temperature metabolic activity is at its maximum.

Table 2: Effect of temperature on snapping frequency in Alpheus malabaricus

Temperature	Snapping frequency		
	in water	in mud	in sand
26°	4.4	5.8	3.6
27°	4.8	6.0	4.0
28°	6.0	8.0	4.2
29°	6.2	11.2	5.0
30°	5.4	9.6	4.6

$\bar{X}^2 = 0.96 < 15.507$

An evident discrimination in the snapping frequency is observed between day and night among different size groups in a muddy substratum as it is the natural habitat which also enhances snapping frequency. The snapping frequency is more during day than night. The large size groups are found to be winners compared to small size groups suggesting the aggressiveness of large shrimps during encounters. The present study also indicates that light plays an important role in snapping since encounters are more in the day than the night. A possible explanation for more snapping during day interactions, and less in night encounters may be due to visibility which is high in the

day than in the night. Thus the present study shows that environmental parameters and muddy substratum appear to influencethe snapping behaviour.

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Feeding And Burrowing Behaviour of the Land Crab, Cardisoma Carnifex (Herbst)

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The land crab, *Cardisoma carnifex* along with *C. hertips* though reported to be distributed in the Coramendal coast of India [1] was not subjected to any serious study except for the work of Kannupandi and Paulpandian [16,17] not to speak of its burrowing and feeding behaviour. Neverthless, extensive investigations of their co–inhabitants, the fiddler crabs *Uca* sps. [2,4,9,18,20,22], has been done. In addition the burrowing habits of Ocypodid crabs [10,14,15], and the pellet crab, *Scopimera proxima* have also been studied[24]. The present study is therefore initiated to meet the lacuna in the knowledge of the burrowing and feeding behaviour of *C. carnifex*.

Material and Methods

Live crabs were collected from Kovalam back waters near the village Karikattu kuppam (12°–46'' L. Latitude and 80°–18'' E. Longitude) situated on the Madras–Mahabalipuram coastal road. They were abundantly distributed near the palm groves and swamps.

In the laboratory crabs were maintained in glass aquarium tanks (62 x 32 x 31 cm) covered with wire mesh. The tanks were earlier filled with the sandy soil brought from the natural habitat spread in an inclined fashion with a maximum depth of 16 cm on one side and 4 cm on the other end. Water brought from the natural habitat was allowed to stand for about 6 cm. Periodical change of water was not necessary as they seem to prefer foul water[25].

Observation

The burrowing behaviour in the laboratory was observed through the glass walls of the aquarium, whereas in the natural habitat careful excavation with mason's spade was performed to trace the course of the burrow. Feeding trails were performed with different food items in the laboratory after starving the crabs for a couple of days.

C. carnifex are found to burrow along the entire bank of the Kovalam back waters, but atleast one metre away from the water edge even when water level increases during the monsoon. However, they seem to prefer to burrow in the shaddy coconut groves. The burrows invariably lead to an enlarged living chamber at the end where water-table is reached. Though occasionally two or three openings are noticed usually each burrow possesses a single opening (mouth) and provided with a raised bund around the opening. The inclined burrows measure from half a metre (when located closer to the water edge) to one and half metres (when away from the water edge). Each burrow is occupied either by a male or female at a time. The burrows located closer to coconut trees showed many criss-crossed roots. In the laboratory tunnel building was clearly observed. The crabs were found to use their walking legs for loosening the soil while the bigger and smaller chelate legs for scooping and carrying the soil To and fro it moved this way and within a short time (30 mts) it

excavated the soil and almost completed the construction of a 35 cm burrow. A wider living chamber was constructed just above the water level in the aquarium. When water was poured gently and the water table raised by a few cm, a new living chamber was constructed at a higher level abandoning the old one which partially got filled up by the soil excavated for the new living chamber. Construction of new burrows were made a few days before the full moon which habit persisted for a few months in the laboratory. During the construction of the burrows when soil particles adhered to the eyes they gently removed them with the help of the palps of the maxillepeds.

Discussion

Even though *C. carnifex* are found near estuaries and back waters, burrows are constructed at least a metre away from the water edge suggesting that they have colonized land but require estuarine, back water or sea for breeding purposes like *C. gaunhumi*[13] *C. carnifex* uses its walking legs for loosening the soil, while excavation operations are done with the chelate legs; soil being carried with chelate legs opposed suggesting that *C. carnifex* is more advanced in the burrowing behaviour, as compared to Dotilla myctinoids which uses only chelate legs for burrowing and soil excavation[23].

The construction of the living chamber just above the water table as well as the inclined burrow may be helfful to keep the burrow cool and moist even during the summer months apart from serving for respiratory purpose. In Ocypods a similar situation is noticed[12] Perhaps the nocturnal habit is also associated with the avoiding of summer heat. Herreid and Gifford[26] have also reported that though burrows are located several kilometres from sea, water is present at the bottom. They also opine that the deeper extension of the burrows may protect the animal from heat and dessication. Even the inclined burrow is to avoid

the direct entry of sunlight[3]. The burrow of *C. carnifex* are usually simple without much complication as seen In *O. platytarsia* where "U" and "Y" shaped burrows were often observed[19]. The operation cleaning of eyes in *C. carnifex* during the construction of the burrows has also been noticed in *U. annulipes*[2] even though only the smaller chelate legs are used here. The presence of single animal in a burrow at a time during the day has a similarity to *U. annulipes*. Borrow construction activity reaching a peak during the full-moon days, persistent for a few months even under captivity may indicate a relation to lunar periodicity. Similar periodicity were observed by Grzimek[13] when the huge female Caribian land crab wandered to the sea in large numbers at the time of full moon and deposited their well developed larvae at the time of spring tides. Kannupandi and Paulpandian[16] have also observed the females of *C. carnifex* migrating to the estuarine shore for spawning around the full moon days.

Regarding the cannibalistic tendency; *C. carnifex* does not show any tendency to eat their own species when well fed and sufficient space in the tank is offered for them. But on the other hand according to George [11] the edible crab, *Neptunus sanquinolentus* Herbst, the bigger specimens are seen to eat the smaller ones, appendage by appendage even though they are well fed on prawns and small fishes.

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Burrowing behaviour of the earthworm Lampito mauritii Kinberg

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The behaviour of earthworms has been studied in a variety of ways from Darwin's time[1]. Some investigators[3,7,9] have studied the behaviour of earthworms in two dimensional surfaces and in mazes. However burrowing behaviour of earthworm in three dimensional units is not known. Therefore the present study employing preparation of wax casts of their tunnels was initiated. The effect of these earthworms on the physical characteristics of the soil and their cast output over a period of 30 days and 15 days respectively were recorded by maintaining these earthworms in pot cultures.

Materials & Methods :

Lampito mauritii used in the experiments were collected from the sandy loam garden soils of Ameer Mahal, Madras. Soil, from the habitat was air dried, sieved through a 425 micron Aimil sieve, mixed with a uniformly dried farmyard manure at a rate of 200 gm of manure/Kg of soil, Amount of water present before drying (20%) was added. The prepared soil with pH of [7,8] was transfered to earthworm cage (62 cms x 31 cms) and also into 5 pots (A,B,C,D&E) with similar quantities of soil by weight (1200 gms of soil/Pot). The earthworms used were Clitellate and selected on the basis of their healthy appearance.

Earthworms (n=12) were introduced into the cage through the upper surface and the set up was left undisturbed in a dark room illuminated with a dark red photographic bulb for 30 days after which melted wax introduced into the cage through the surface, was allowed to harden for 2 Hrs and the surrounding soil was removed by a jet of water to identify the regions of activity. Worms were introduced into the pots at the rate of one in A, two in B, three in C, four in D and five in E.

Porosity and water holding capacity of the soil were determined using Keen's Cups[5] at the time of introduction of the worms into the pots and thereafter at the end of every 10 day period for a period of thirty days. Surface casts were cleared every day from the date of introduction of the worms from the 5 pots (in triplicate) for 15 days, dried at 100°C, weighed and recorded.

Results :

During the period of observation worms show vertical migration and very often more than one worm was observed in a single burrow within the cage. The pattern of burrows after the preparation of wax cast exhibit no apparent regularity. Each burrow connects another to form a net work of burrows, the structure being more prominent in the first 30 cm below the soil surface.

The dry weight of casts over a period of 15 days, (in triplicate) is at an average of 0.25 gms/day in A, 0.53 gms/day at the rate of 0.26 gms/day/worm in B, 0.34 gms/day at the rate of 0.11 gms/day/worm in C, 0.59 gms/day at the rate of 0.15 gms/day/worm in D, 0.42 gms/day at the rate of 0.08 gms/day/worm in E. (Table)

Porosity and water holding capacity of soil before and after the experiments (30 days) is shown in Table.

Table : Porosity (%) and water holding capacity (%) of soil prior to and after the introduction of earthworms.

Initial Porosity = 47.09%

Initial water holding capacity = 34.88%

Pot	Porosity	Decrease %	Water holding capacity	Increase %
A	46.54	1	37.42	7
B	40.20	15	37.64	8
C	46.51	2	37.03	6
D	45.71	2	36.64	5
E	48.78	4*	38.46	9
Mean	45.55	3%	37.44	7%

* Increase (mean value)

Discussion :

Activities of earthworms influence the soil structure by ingestion of soil, partial breaking down of organic matter, which are thrown out as surface casts. By burrowing through the soil they bring out sub-soil to the surface. During these processes, they thoroughly mix the soil and form water stable aggregates; aerate the soil and improve the water holding capacity.

Lampito mauritii is a surface dweller, migrating to deeper layers during summer. Provided with optimal conditions in the cage, they show dense surface activity inspite of their 3 dimensional movements inside the cage. This surface activity leads to the deposition of surface casts and in bringing the sub-soil to the surface.

The burrows of *L. mauritii* have more than one opening and do not follow the constant pattern of "U" shaped burrows described by earlier investigators for *Allolobophora caliginosa*.[6]

Surface activity of *L. mauritii* within 30 cm of the surface soil is more prominent in the deeper layers.

Large amount of soil from deeper layers has been reported to be brought to surface by earthworm activity.[2] The amount of soil turned over in this way differs greatly with habitat and geographical region ranging from 2 to 250 tonnes/ha. In addition, large amount is deposited as sub-surface casts so that the total soil turnover is even greater.

L. mauritii produced at an average 0.17 gms of surface cast/worm/day. This value may vary subject to availability of food and proper conditions. Increase in cast out-put by nearly 40% was observed on the day succeeding the day of providing organic nourishment to the culture. Addition of farmyard manure to the pots on the 4th day considerably increased cast output to nearly 0.33 g/worm.

Apparently though a specific pattern of cast out-put does not appear in culture most frequently pot E shows higher values than pot D followed by pot C, pot B and pot A. Conversion of these values to castings/worm/day shows a mirror image with pot A being followed by B,C,D and E with reference to cast output. This probably is due to crowding as the space occupied by 5 worms in E is equal to the volume of space occupied by a single worm in pot A. That, crowding affects metabolic activity especially with reference to oxygen consumption in *L. mauritii* has already been established.[3] Crowding probably checks the tunnelling activity of worms thereby restricting cast output. Moreover individual physiology of the earthworms will considerably vary affecting total output of casts.

Earthworms improve soil aeration by their burrowing activity, and also influence the porosity of soil by their effect on soil structure. It is shown[8] that earthworm activity increased the porosity of two soils from 27.5% to 31.6% and from 58.5% to 61.8% respectively thus indicating clearly that earthworms greatly increase the aeration and structure of soils.

In the present study surface casts were cleared everyday to record their activity so that the benefit of worms on surface soil was eliminated. Hence soil devoid of castings in the culture pots showed only a slight increase in their water holding capacity but a decrease in porosity in all the 5 pots. Water holding capacity at an average increased by 7% whereas porosity apparently decreased by about 3% during the period of study (Table). The increase in water holding capacity and decrease in pore space in sub-surface soil was about 0.015% and 0.014%/worm/day at an average.

Thus this investigation confirms no apparent regularity in the pattern of burrows of *L. mauritii* with their activity being more prominent within the top 30 cm of the soil. This species produces at an average 0.17 gms of surface casts/worm/day with the single worm in pot A showing more output than 5 in pot E in terms of cast output/worm/day.

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Substrate Preference of Apseudes Chilkensis Chilton

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The relative tactile, locomotory and burrowing behaviour of benthic invertebrates inhabiting the estuarine biotope have been observed in relation to the nature of substratum, different particle size of the sediment and their composition [1,2,3,5]. *Apseudes chilkensis* for their preference towards different substrates viz. natural sediment, glass beads, medium sand and fine sand have been investigated by conducting various experiments using the standard procedures as adopted by earlier workers [15]. An attempt has been made to investigate its burrowing behaviour when exposed to light and dark conditions.

Methods and Materials

The test animals were collected from the subtidal regions of the Coleroon estuary. The bottom sediment sample was collected by Petersongrab and were sieved through 0.5 mm mesh-sieve and the animals picked by using pipette. They were kept in finger bowls with filtered estuarine water for 3 days and healthy animals were alone used for the experimental studies. Sediment sample collected from the same area was used as the substrate for all the experiments. The natural sediment was also washed with fresh water and air dried and then sieved through ASTM 60, 120 mesh sieve in order to obtain medium sand (0.25 to 0.50 mm)

and fine sand (0.125 to 0.250 mm). The glass beads with size range of 0.125 to 0.500 mm were treated with concentrated nitric acid to remove impurities and later washed atleast 5 times with distilled water. The pipette analysis of natural sediment was done as described by Krumbein and Pettijohn [5] for percentage composition study.

Three fourth of the petridishes (15 cm diameters) were filled with filtered estuarine water. The graded, medium sand, fine sand, natural sediment and glass beads were placed at the centre of each petridish and animals were release into the petridish. The animals once used were discarded and fresh animals were used for subsequent experiments. Each time 25 animals were released. By substracting the number of animals moving away from the sediment or swimming in the water column from the number released into petridish (ie 25), the number preferring substratum was obtained. In the second series of experiments where number released was not known, a direct count or animals actually present buried in substratum was taken after disturbing each substratum.

The experiments were also done in dark and light conditions using dark and light chambers for phototactic behaviour. Here the illumination was made by an artificial light (440–650 lux) and the observations were made once in 4 hours.

Contingency chi-square analysis was applied to test the homogenity within the replicates and among different substrates. The significance of the choice ratio in different experiments was tested by the chi-square test using Yates correction for continuity [6].

Results

Experiments carried out with natural sediment, glass beads, medium sand and fine sand each in separate petridishes for substratum selection study showed that *Apseudes chilkensis*

Table 1. Observations in natural sediment, glass beads, medium and fine sand.

Experiments	No	Number of animals inside the substrate				Mean	Mean of mean values	X^2 after 4th hr	P
		1 hr	2 hr	3 hr	4 hr				
Natural sediment	1	20	25	—	—	22.5		23.04	0.005
	2	25	—	—	—	25.0	24.16 (96.66%)	23.04	0.005
	3	25	—	—	—	25.0		23.04	0.005
Glass beads	1	19	19	18	23	19.75		16.00	0.005
	2	17	21	22	23	20.75	19.50 (78.0%)	16.00	0.005
	3	15	17	20	20	18.00		7.84	0.01
Medium sand	1	10	16	20	20	16.50		7.84	0.01
	2	13	16	18	21	17.00	16.60 (66.33%)	10.24	0.005
	3	9	17	18	21	16.30		10.24	0.005
Fine sand	1	2	5	5	6	4.50		5.76	0.01
	2	0	1	3	4	2.00	3.66 (15.86%)	10.24	0.005
	3	4	3	5	6	4.50		5.76	0.01

Table 2. Observations in different samples of substrate after 4 hours

Sample	Number of animals burrowed	Number of animals not burrowed	Total
Natural sediment	25	0	25
Glass bead	22	3	25
Medium sand	21	4	25
Fine sand	5	20	25

$X^2 = 131.89$, $P < 0.005$, with 2 degrees of freedom, in a 2 x 4 contingency table of the number of animals in the two choices in each of the four samples of substrate.

Table 3. Choice experiment with medium and fine sand.

Experiments	Medium sand	Fine sand	Total	X^2	P
1	19	6	25		
2	20	5	25	15.41	0.001
3	16	9	25		
	73.33%	26.66%			

X^2 value with 2 degrees of freedom.

Table 4. Observation in natural sediment and glass beads after 4 hours.

Experiments	Number of animals observed in		Total	X^2	P
	Glass bead	Natural sediment			
1	2	23	25	16.0	0.005
2	3	22	25	12.76	0.005
3	5	20	25	7.84	0.005
Total	10 (13.33%)	65 (86.66%)	75		

Table 5. Choice experiment between glass bead and natural sediment.

Experiments	Number of animals observed in		Total	X^2	P
	Glass bead	Natural sediment			
1	10	65	75	38.38	0.01

Table 6. Observation in dark and light conditions after 4 hours.

Experiments	Number of animals observed in		Total	X^2	P
	Dark	Light			
1	24	1	25	19.36	0.005
2	20	5	25	7.84	0.005
3	23	2	25	16.00	0.005
	67	8	75		
	(89.33%)	(10. 66%)			

In choice experiment between light and dark conditions showed with 2 degrees of freedom.

$X^2 = 47.8$, $P < 0.001$.

preferred natural sediment (96.66%), glass beads (78.0%), medium sand (66.33%) and fine sand (15.86%) in that order (Table 1 and 2). From the choice experiment study it was inferred that *A. chilkensis* preferred medium sand (73.66%) (Table 3). The observations made from the experiments conducted by keeping the glass beads and natural sediment side by side in the same petridish indicated a well pronounced preference of these animals towards natural sediment (86.66%) than the glass beads (Table 4 and 5). The result of the light and dark experiment

showed that the burrowing activity of *A. chilkensis* was more into the substrate during dark condition (89.3%) than in light condition (Table 6).

Discussion

The substratum selection of the amphipod *Corophium* sp which live in soft sand and mud was worked out by Meadows [5] He suggested that amphipods opted their own substrate when they were given choice to choose different types of substrates. Even the level of illumination and colour of the substrate also had very little effect. Similarly, Gray [1, 3] while studying an interstitial archiannelids *Protodrilus symbioticus* and *P. Hypoleucus* reported that these archiannelids also preferred the natural substratum as well as medium sand grain size (0.25-0.50 mm). Further he had ascertained that these interstitial archiannelids showed a thigmotactic behaviour too. The present study is in confirmity with those of Meadows [5] and Gray [1,2]. However experiments with regard to the level of illumination *A. chilkensis* preferred the dark condition than the light. It substantiates the investigations of Gray [1] but not that of Meadows [5] who showed that both dark and light are equally preferred by amphipod *Corophium*. The present study also confirms the view of Gray [5] with regard to the preference of natural sediment when animals were given the choice of glass beads and natural sediment kept at different sites in the same petridish.

Although over 60% of the natural sediment was composed of medium sand, *A. chilkensis* was found to prefer the natural sediment than the medium sand. This may be due to the other attractive factors like bacteria and external metabolites. Gray [1] in his studies on archiannelid *Protrodrilus rubropharyngeus* and Meadows [5] on *Corophium* sp have proved that these animals were attracted by the presence of specific bacteria or by external metabolites.

In general, the attraction of animals to particular substratum involves many factors such as food, presence of microbial population, thigmotactic effect of the sand particles, oxygen content and chemical properties [6,9,14]. However, from the present study it was inferred that the benthic active burrowing invertebrates like Tanaids mainly prefer the bulk of the major composition of the natural sediment than any other factor and this may also be happening in other crustaceans.

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Ecological and Behavioural Studies on the Estuarine Burrowing Eel Moringua Raitaborua from Portonovo Waters

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The worm eel *Moringua raitaborua* generally inhabits the muddy creeks of tropical estuaries. But at Portonova this is often found both in fresh water channels and salt pans[7], an unique adaptation seen in this eel. In the Vellar estuary the area where this eel occurs in relative abundance, is often subjected to wide fluctuations in salinity, oxygen content, temperature, substratum and pH.

The objective of the present investigation is to know whether, the above ecological factors have any significant effect on their distribution.

Material and Methods

Specimens of *Moringua raitaborua* were collected from the muddy creeks of Vellar estuary, brought to the laboratory and kept alive in aquarium tanks containing filtered estuarine water and substrate from original habitat. Salinity and oxygen content of water from where the eels were obtained as well as the artificial environment provided at the laboratory were made by the methods of Harvey[3]. Experiments for substrate selection and salinity tolerance were carried out following the procedure

given by Subramanian[7,8]. A simple continuously monitoring apparatus for respiration studies designed by Lingaraja *et al.*[4] was used for oxygen consumption estimation.

For colour discrimination experiment a Perspex tank (of the dimension 58 x 48 x 25 cm) was used. The bottom was provided with black, brown, green and yellow colour papers of 29 x 24 cm each. Twenty animals of 130–140 mm in length were released and the number of animals at each coloured bottom were counted after 24 hours. The presence of head was taken as preference for the colour by the animal. The experiment was repeated by changing the position of the colours.

A perspex tank (38 x 24 x 24 cm) was separated into two equal chambers by means of a partition and one chamber was completely covered with black cloth. Provisions were made in the form of holes at the bottom of the partition for the free movement of the animal from one chamber to the other. No extra light was provided to the light chamber during day time. Ten animals (125–135 mm) were released and the number of animals in the light chamber was counted after 24 hours.

The effect of height of water column on the burrowing behaviour of the eel was studied using cylindrical specimen jars (40 cm height and 12 cm diameter) in which the natural substrate was provided to a height of 15 cm. Water column was maintained to a height of 4 cm above the substrate. As the animal was released it burrowed into the mud and came to the surface after forming a 'U' shaped tube. The height of the animal exposed above the substrate was measured by means of a scale fixed earlier. The same experiment was repeated by increasing the height of the water column.

The same jar with a substrate height of 15 cm and height of 15 cm water column with regulated temperature was used to study the effect of temperature on the burrowing behaviour.

Results

M. raitaborua is usually found buried in the mud during low tide but lead a free swimming life during high tide[9]. In laboratory experiments the height of the water column in the container appeared to influence the burrowing behaviour of the eel, the height of the animals exposed increasing with an increase in the height of the water column. Out of the two size groups of eels studied (130–135 mm and 136–140 mm) the height of the water column had a profound influence only on the latter group (Table 1).

Table 1. Height of water column effect on burrowing behaviour.

	Height of water column (mm)	Length of animal exposed (mm)	
Size Group: 130–135 mm	20	7.5	
	40	20.5	
	80	51	
	120	75	
	160	83	r value 0.9278
Size Group: 136–140 mm	20	6.6	
	40	20	
	80	31	
	120	62.5	*
	160	44	r value 0.7424**

* Significant at 5% level
** Significant at 1% level

Table 2. Raw data of the Oxygen consumption rate at different salinities (ml/gr/hr)

Salinity (%)							
0	10	20	30	40	50	60	70
0.21	0.1034	0.0355	0.0162	0.012	0.132	0.1976	0.0978
0.24	0.04	0.06	0.025	0.112	0.133	0.1337	0.2382
0.92	0.037	0.09	0.053	0.112	0.097	0.0988	0.0936
	0.07	0.09	0.07	0.112	0.09	0.0988	0.24

Student Newman Kaul Test - Anova

Source of variation	Sum of squares	Degrees of freedom	Mean squares	F
Total	0.7542726	30		
Group	0.3968346	7	0.0566907	3.6479*
Emor	0.357438	23	0.0155408	

* Significant at 5% level

Experiments on salinity tolerance, and rate of oxygen consumption of the eel at different salinities (Table 2) indicated the ability of the animal to tolerate a wide range of salinity (0 to 75%). Minimum oxygen consumption was observed at 30% salinity. However, changes (either decreasing or increasing) in salinity enhanced oxygen consumption rate of the eel. Application of the Student – Newman – Kaul test at 0.05 level revealed that salinity had significant effect on the rate of oxygen consumption.

Among the various combinations of the substratum provided (Table 3 & 4) majority of the eels preferred the sediment

Table 3. Substrate selection (No choice experiment) Chi square

Substrate	Burried	Not burried	Total	x^2
1.	98 (50)	2 (50)	100	92.16
2.	92 (50)	8 (50)	100	70.56
3.	90 (50)	10 (50)	100	64.00
4.	90 (50)	10 (50)	100	64.00
	370 (200)	30 (200)	400	289.00

x^2 interaction = 290.72 – 289.00; 1.72 ns

Table 4. Substrate selection (Choice experiment) Kolmogorov – Smirnov Goodness of fit.

I	II	II	IV	V
0	17	10	6	27
12	12	12	12	12

D = 0.25* P ∠ 0.05

They do not distribute evenly

* Significant at 5% level.

substratum obtained from the region where the eels occur in heavy concentration in the Vellar estuary. Preference for dark colours was observed in the colour discrimination (Table 5) and light and dark chamber experiments.

Table 5. Colour discrimination
Kolmogorov – Smirnov Goodness of fit.

Dark	Brown	Green	Yellow
58	30	6	6
25	25	25	25

$D = 0.38^*$ $P < 0.05$

They do not distribute evenly
* Significant at 5% level

Discussion

Though the ideal habitat of *Moringua raitaborua* is brackish water the eel predominantly occur in the muddy creeks of Vellar estuary at Portonovo. The mean hydrographical parameters such as salinity, dissolved oxygen content, temperature and pH of the water of this area were 29.33%, 3.75 ml/l, 30°C and 7.3 respectively. The substratum consisted mostly of soft mud with an admixture of sand with decaying organic matter. However, this habitat of the eel is often subjected to wide fluctuations in salinity, due to riverine inflow. But the eels were not disturbed, because the interstitial salinity was affected only at a much slower rate than that of the overlying water as reported by Reid[6].

Eels were generally known to tolerate wide salinity fluctuations. However, at extreme salinities (75% to 80%) they exhibited marked morphological changes such as shrinkage of the body skin, discoloration associated with profuse mucus secretion, leading to death as observed in the present study.

Though no definite relationship was noted between salinity and oxygen consumption, the minimum oxygen consumption was observed at lower salinities (30%) as observed by Rao[5] and Farmer and Bearmish[2]. Perhaps this inverse relationship may be an adaptation to the osmotic and ionic regulations of the animal. The linear relationships observed between the height of water column and length of the animal exposed may be due to the respiratory requirement of the eel. However the temperature does not appear to influence burrowing behaviour of the eel significanly.

Substrate selection experiments conducted with four different types of substrates indicated their preference for the natural habitat. As many as 40 animals per m^2 were found in muddy substrate whereas the number was less in areas where the substrate was more sandy. This might be because the animal can burrow through the soft mud with relatively greater ease and hence the preference for the natural type of habitat.

Colour discrimination experiments revealed preference for black colours rather than light colours. Preference for black colour indicated their photonegative nature. The presence of a large number of animals in the dark chamber in the dark and light chamber experiments conducted confirmed this fact.

Essentially the present investigation showed that the substrate is an important factor controlling the distribution of the eel. The other parameters may not have much effect on their distribution.

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Mating Behaviour and Oviposition in Odontopus Vericornis

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Studies on mating behaviour in insects have shown that the mating stimulus increases fecundity in a number of insects.[4] Virgin females have been known to retain their eggs even though an ideal oviposition site is available.[3] The male accessory glands (ACGL) secretory product has been shown to contain a factor which when transferred to females during copulation stimulates oviposition in *Drosophila melanogaster, Drosophila funebris, Aedes aegypti, Schistocerca gregaria, Melanoplus sanquinipes*[4] and the moth *Zeiraphera diniana*[2] It is also known that direct stimulus to egg laying is by blood borne factor since injection of haemolymph from ovipositing insects induces oviposition in gravid females of *Iphita limbata, Schistocerca gregaria* and *Bombyx mori*.[4] Further in *Lymantria* and *Ephestia* it has been shown that the ACGL of males do not influence oviposition[2]. Because of the conflicting roles of the ACGL and paucity of information about it generally in insects and particularly in Hemiptera, the present study of the role of the ACGL in mating behaviour and oviposition in *Odontopus vericornis* was initiated.

Material and Methods

Specimens of *O. Vericornis* were collected from the gardens and sports pavilion of Annamalai University and reared in the laboratory. The insects were maintained in standard cages of 15" x 18" x 15" dimensions, under laboratory conditions of 12/12 day/night and 80% humidity. The insects were fed daily

on soaked and germinating cotton seeds. A bed of fine sand was spread at the bottom of the cage which served as an oviposition site.

Four day old specimens (five pairs), were used for all observations on mating bevaviour. They were kept in standard cages from the first day after imaginal moult. From morning 8 a.m. to evening 5 p.m. the males and females were kept together or observation and were kept separately during the rest of the time. The following activities were considered as sexual behaviour: 1. *Chasing* – the male after perceiving a female actively follows the female from the fourth day adult life.

2. *Mounting*: the male crawls over the body of the female and simultaneously protrudes its sharp aedaegus, 3. *Mating*: after gripping the female tightly the male inserts its aedaegus forcibly into the genitalia and remain in an end to end position.

Extirpation of the gonad: After ether anaesthetisation two small incisions were made on the ventro-lateral integument of 2 & 3 abdominal segments. The gonads were gently pulled out and by holding it gently with fine watch-maker's forceps they were removed and immersed into insect ringer. The wounds were sealed with soft wax after placing a few crystals of streptomycin sulphate.

Extirpation of the ACGL: Two small incisions were made as described above on the 7 & 8th abdominal segments on the ventral side. The ACGL was removed by holding its base tightly by a watchmaker's forceps and the wound was sealed with molten low melting point soft wax. One or two crystals of streptomycin sulphate was placed on the wound before it was sealed.

Observation

Sexual responses were noticed only from the fourth day after imaginal moult. Males chase females very actively after courting a particular one. The male rubs and scratches all over the body of the female by its antennae and palpi. While it does so its aedaegus darts out. Usually more than one male vie with each other for a female. Male mounts over the female with its aedaegus projected and clutches the body very firmly. Once the

female is within the grip of the male, it is passive and the male forces its aedaegus into the genitalia of the female and they get entangled through their genitalia and assume an end to end position. This is known as "Copula" position. In natural and

"Copula" position of O. Vericornis

controlled conditions the characteristic behaviour of *O. Vericornis* is that they are found mostly in pairs copulating in end to end position from the fourth day of adult life to the 20th day, of its overall 25 days of adult life. All normal and usual activites like roaming, feeding, excretion etc., are carried out by the copula with ease. While they do so other males try to mate with the female in copula and this attempt is resisted and thwarted by the female. Gradually the abdomen of the female begins to swell and by 10/11 day it is bloated conspicuously due to the development of the oocytes in the ovary. The female breaks away from the males on the 11th day and oviposits about 120 eggs in about 3-4 hours. (Table) After ovipositing the last few eggs the female rests. It does not move about actively or feed. 2-3 hours after oviposition they respond once again to a male very quickly and copulate the next moment. The pair remains in copula for another week. On the 17/18th day the female breaks away finally from the male and oviposits about 80-90 eggs. After this second oviposition the female and male lead a scenescent life. They are mostly inactive and remain isolated.

In one set of experiment where sexually mature females alone were kept in a cage they were found to exhibit copulating tendency by mounting one over the other eventhough the attempt is futile and did not oviposit eggs.

In another set of experiment a batch of ten males were gonadectomised on their second day of adult emergence and were left with females. The males chased, mounted and copulated with females like normal males except that they get separated from females slightly earlier, the females oviposit 55-62 eggs during the first oviposition and 42-48 eggs during the second oviposition. (Table)

Table: Oviposition rate and influence of male accessory gland on oviposition in *Odontopus vericornis*

Experiment	Oviposition	Day	No. of eggs laid.
Normal females	1st oviposition	10–11	120 ± 10
	2nd oviposition	17–18	80 ± 10
Isolated females		12	5 ± 5
Females with gonadectomised	1st. Oviposition	10–11	55 ± 8
males	2nd Oviposition	17-18	42 ± 6
Females with ACGL extirpated males		12	3 ± 2

In the third set of experiment 2 day old 20 males with AGGL extirpated were left with females. Except for erratic and inconsistent chasing of females and rare attempts to mounting, no sexual response was seen in these males and they failed to mate. Injection of aqeous extract of the accessary gland, rather than its implantation, revoked sexual responses in males and they mated with females.

Discussion

The present investigation of behaviour of *O vericornis* revealed that gonads are not necessary for mating or for oviposition. It further showed that ACGL in males is required for mating and the rate of oviposition is increased only after mating.

It substantiates the earlier observations. It has been shown in *Schistocerca gregaria, Drosophila melanogaster,* and *Aedes aegypti* that implantation of male ACGL into females invoked an increase in the number of eggs produced[4]. Pickford *etal.*,[8] have shown in *Melanoplus sanguinipes* that the secretion of ACGL stimulates egg laying and it has been confirmed by Friedel and Gillott[4]. Benz[2] has observed a similar effect in *Zeriraphera diniana*. Extensive studies have been carried out only in dipterans where the ACGL secretion has been shown unequivocally to promote fecundity[7]. However in *Locusta migratorio manilensis*[5] and in *Teleogryllus commodus*[6] the ACGL has been shown to have no influence in promoting oviposition. The behaviour of gonadectomised males which mate normally and cause oviposition in female like an unoperated animal indicated that sperms are not necessary for initiation of oviposition. However reduction in number of eggs oviposited showed that sperms, in addition to ACGL substance are necessary for normal oviposition as has been suggested by Leypold.[7] It appears that mating itself is sufficient to increase fecundity in *O. Vericornis* as in number of other insects[8].

A fine bed of sand known to be an ideal site which alone can stimulate oviposition [3,8] did not cause oviposition in virgins of *O. vericornis*. The females oviposited only after mating with a male with its ACGL intact, which reinforced the necessity of ACGL substance for oviposition.

Though mechanical, nervous, chemical and sperm effect factors are known to increase ovarian production in insects[7] the recent findings seems to suggest the interplay of nervous

system and endocrine system. Friedel and Gillott[4] have hypothesized that the ACGL substance moves across the spermathecal wall into the haemolymph and hence to the brain. They showed circumstantial evidence in *Melanoplus sanguinipes* indicating the effect of the ACGL substance on oviposition by neurosecretion via the brain. It is possible that such neurohaemally activated mechanism as suggested by Friedel and Gillott [4] played a role in oviposition of *O. Vericornis.*

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Gravid Parasitic Isopod-Induce behaviour in Marine Eel

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The behaviour of an eel *Pisodonophis Boros*[1] during its infection by a cymothoan parasite *Agarna Malayi*[3] under laboratory conditions is interesting. Host seeking and attachment of the parasite to the eel for releasing eggs, and the loop forming behaviour of the host eel to get rid off the parasite are the interesting aspects described here. The isopod parasite was collected alive from the gill cavity of a clupeid fish *Nematalosa nasus*. The host eel was obtained from the muddy creeks of Vellar estuary, Porto-novo, South East coast of India. Fully mature female parasites maintained in tanks containing filtered sea water tried to hold on to the body of the eel. But the eel avoided it by exhibiting peculiar body movements. After a series of attempts, the parasite got attached successfully. The very next day of infection the parasite released the eggs in the tank.

During infection the eel exhibited behavioural pattern of avoiding the parasite by formation of loop. Even the proximity of the parasite to the host in the tank caused in the host eel a few loops first in the form of eight with the head through one end and tail through the other. The eel formed a knot in such a way that the head can be retracted through the loop to free

itself quickly from the parasite similar to that seen when attacked by its predator octopus.[2]

In addition to loop formation the eel showed profuse mucus secretion, and vigorous wriggling movements to prevent the parasite from getting a firm attachment to it. However, the parasite adapted remarkably and got a firm hold on the host. The liberation of eggs was found to occur only after getting a firm grip on the host. It indicated that the parasite depends on the host somehow to shed the eggs.

Though the host specificity is very well pronounced, it is obvious from the present observation that when necessity arises, the parasite may take to other hosts readily available in the absence of its usual host for the sake of reproductive purposes.

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Time Budgets of the Captive Budgerigar, Melopsittacus undulatus

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Every animal has a finite amount of time (and energy) for activities of self maintenance and reproduction. The way an individual apportions this time ultimately influences its survival[16] and reproductive success[6]. Presumbly, for any given set of environmental circumstances, there is an optimum time budget, and natural selection will favour individuals that exhibit this optimal budget[17,21]. Detailed studies of time budgets can help in evaluating the costs and benefits associated with a particular mating system and reproductive strategy, as well as in the elucidation of adaptive significance of the mating system in the particular ecological context of the species[5].

The objective of the present study was to document the time budgets of the captive budgerigars by sex and stage of breeding cycle. The results have been discussed in relation to the efficiency of mating system and reproductive strategy of the species.

Material and Methods

The budgerigar (*Melopsittacus undulatus* Shaw) belongs to Psittacidae family and inhabits the dry grasslands of

Australia. This highly colonial and nomadic species breeds after heavy but characteristically sporadic rainfalls. No nest is built. Pairs are typically maintained for the life of one member. In captivity, they breed easily in earthen pots and show nearly full spectrum of the typical behaviour of the species.

The budgerigars were housed in large indoor aviaries (size 3 x 1 x 2 mtrs.) and were maintained on *ad libitum* diet consisting of mixed millet seeds, germinated wheat cereal, spinach, cuttle fish bone, quartz gravel and fresh water. Birds were provided with earthen pots for breeding purpose.

Time budgets were determined for randomly selected and individually identified, 4 males and their mates by instantaneous sampling[20] at 15 - second intervals, of 20 predetermined behaviours. During 30 - minute instantaneous sample periods (at least four in a day), the observer watched both a female and her mate (often two pairs), simultaneously. Every 15 seconds, at the tone of an electronic timer alarm, the activity of each bird was recorded on to a cassette tape in a tape recorder. Each sample yielded 120 data points per bird. A total of 320 bird hours of instantaneous sampling accumulated 76,800 data points.

Since entering the area usually disturbed the birds slightly, the observer arrived in the hide 15 minutes prior to the start of a sample. Birds typically returned to their normal activities in less than 5 minutes.

Time budget data for all the birds were categorized by sex and stage of breeding cycle (prelaying, laying, incubation, and brood periods). More than twenty behavioural categories were clumped into the 10 activities defined below :

1. *Foraging*:

Walking about pecking at food items, drinking.

2. *Preening*:

This behaviour category comprises 5 activities: scratching head or beak, Preening with the beak, Cleaning feet with the beak, shaking, rubbing the head on wings and back. Reciprocal preening (or allopreening – when one budgerigar nibbles the head plumage of another) was also included in preening, if it occurred between non–mates.

3. *Resting*:

A budgerigar shows none of the protocolled behaviours and sits 'drowsily' on the perch or inside the nest–pot (only females during prelaying period).

4. *Walking & Flying*:

Flying and walking about without pecking at food items.

5. *Courtship*:

This includes courtship, singing, precopulatory behaviour patterns (such as: head–bobbing, nudging, head shaking, approach and retreat from the mate, beak–hooking), and copulation and soliciting copulation.

6. *Courtship Feeding*:

Male regurgitates food and feeds the female in beak-to-beak contact. Courtship feeding is essential part of courtship but we have analysed it separately for better understanding.

6a. *Adult food begging*:

Female turns towards the mate, the upper mandible quivers up and down and finally, food provided by the male, is ingested. This behaviour is complementary to the courtship feeding.

7. *Agonistic behaviour*:

Includes supplanting attack, beak thrust, sidling towards the opponent. Flying and sidling away from the opponent and appeasement displays are also components of this behaviour category.

8. *Incubation*:

Sitting on the egg when at least 1 egg is present.

9. *Feeding the nestlings*:

A budgerigar regurgitates food and feeds the nestlings in beak-to-beak contact.

10. *Brooding*:

A budgerigar sitting with or sheltering one or more nestlings inside the nest–pot or 'perched alert' on or near the nest–pot.

Results and Discussion

Table shows the mean time budgets (%) by sex and stage of breeding cycle.

1. Sex differences

To determine whether there were differences between females and their mates in proportion of time spent in each behaviour during the prelaying, laying, incubation and brood periods, we conducted a treatment x subject design[22], where subjects were pairs of budgerigar and the treatment was sex.

During the prelaying period females foraged and preened less than males ($p < .05$), and rested more ($p < .01$). Differences in the other behaviours were not significant.

TABLE

Time budgets (%) by sex and stage of breeding cycle ± 1 S E.

Behaviour	Stage	PRELAYING (PL)		LAYING (L)		INCUBATION		BROODING (B)	
	Sex	Male	Female	Male	Female	Male	Female	Male	Female
1. Foraging (F)		17.1±2.0	12.2±1.3	26.3±3.2	6.9±0.8	25.4±3.0	8.7±1.1	26.1±3.3	13.2±1.5
2. Preening (P)		6.7±0.4	5.6±0.3	11.2±1.4	3.5±0.8	12.5±1.2	5.2+0.7	5.6±0.7	4.0±0.3
3. Resting (R)		14.1±1.6	22.7±2.2	9.1±1.0	2.8±0.6	13.7±1.6	3.3±0.4	10.1±1.0	8.5±0.2
4. Walking and Flying (WF)		16.3±1.8	16.1±2.0	11.7±1.3	7.7±1.0	15.5±1.1	6.5±0.8	11.3±1.2	9.4±1.0
5. Courtship (CS)		25.2±2.3	23.8±2.6	18.6±1.6	16.1±1.5	17.3±1.2	7.6±0.7	22.2±2.1	17.4±1.9
6. Courtship feeding (CF)		6.0±0.9	—	12.8±1.5	—	10 2±1.1	—	9.3±0.9	
a. Adult food begging (AB)		—	6.0±0.8	—	12.8±1.4	—	10.2±1.3	—	10.2±1.4
7. Agonistic (AG)		14.3±0.9	13.6±1.1	10.4±1.0	6.2±0.8	5.4±0.9	5.1±0.7	6.1±0.5	11.1±1.3
8. Incubation (I)		—	—	—	43.9±4.7	—	53.4±6.1	—	—
9. Feeding the nestlings (FN)		—	—	—	—	—	—	8.2±1.0	9.2±2.2
10. Brooding (BR)		—	—	—	—	—	—	1.1±0.3	17.0±3.6

During the laying period females foraged, preened, rested and walked and flew less than males ($p < .001$, $p < .001$, $p < .001$ and $p < .01$ respectively). The time saved from all these activities was utilised by the females for incubating. which remains the major activity during the laying and incubation periods. Males never incubate.

Sexes differed significantly in every behavioral category during incubation but for courtship feeding/adult food begging and agonistic behaviour. Females spent more than half of their time incubating the clutch and males foraged, preened, rested, flew and courted more than females in this stage of breeding cycle ($p < .001$ for every behaviour).

During the brood period females spent more time in agonistic encounters and brood guarding ($p < .01$ and $p < .001$ respectively), while males foraged and preened more than females ($p < .01$ and $p < .05$ respectively).

Intrasexual changes in time budgets over the course of a breeding cycle were caused by variety of factors, but the most notable differences were the result of difference in the strategy of males and females. Males maximise their reproductive success by foraging for the mate and brood, while the female achieves the same goal by devoting most of her time for incubating the clutch and brood defence.

Incubation time influences some behaviours more than others. Comparison of female prelaying and incubation behaviour indicates that time spent preening, foraging, courting and resting decreased considerably. Resting, particularly, had the lowest priority during incubation. Resting and incubation are behaviourally and energetically similar, suggesting that a bird can 'rest' while sitting on the nest. Similarly, Siegfried et al.,[19] reported that the time used for incubation by female

maccoa ducbs, *Oxyura maccoa* was largely made up of time spent resting by non-breeders. Incubation substitutes for resting in Lapland longspurs, *Calcarius lapponicus* [4]; avocets, *Recurvirostra americana* [7]; and polyandrous spotted sandpiper, *Actitis macularia* [13] as well.

2. Stage of breeding cycle differences

A repeated measure design [22] indicated that time spent in almost every behavioral category changed significantly among stages of breeding cycle.

Females foraged less during laying than prelaying, due, in part, to the time spent incubating ($p < .01$). Males however, remaining free from the duties of incubation, foraged more during laying than prelaying ($p < .05$) and compensated the loss in foraging time of female by devoting more time in courtship feeding ($p < .001$). The proportion of time spent foraging by males remains consistently high through incubation and brood period as well, because of the responsibility of feeding the female and the nestlings. Females, however, engaged more in foraging ($p < .05$), only during the brood period when they had to feed the nestlings.

Time spent preening by females decreased considerably during the laying through brood period ($p < .01$), presumably because of the time spent incubating and time spent brooding is increased. Males, however, preen more when females incubate (*i.e* during the laying and the incubation periods), and return to normal levels during the brood period ($p < .01$, and $p < .001$ respectively). Most of this increase in preening seems to be 'displacement activity', a consequence of lesser availability of mate for courtship.

Female resting time dropped markedly, during the laying and the incubation period, before increasing again during the brood period ($p < .001$). This pattern suggests that incubation

is the most important activity for females, and time is spared for incubation by minimizing rest and other maintenance activities. In an effort to replenish the depleting energy of the mate during laying, males had to devote considerable proportion of time in two activities – foraging and courtship feeding. Further, during the brood period, male had to feed the female and the nestlings. Consequently, male resting time remained at its lowest ebb during laying period and brood period.

Both the sexes flew and walked less during laying than prelaying (male $p < .05$ and female $p < .001$). Males return to the prelaying levels during incubation but again minimise walking and flying to conserve energy during hectic brood period ($p < .05$). Females walked and flew considerably more during the brood period to cope up with the requirements of guarding and feeding the nestlings and courting the mate ($p < .05$).

Courtship was highest during prelaying, but steadily decreased thereafter, with copulation typically ceasing after the last egg was laid (male $p < .05$, female $p < .001$). The pair bond is maintained throughout life in budgerigar, and since courtship (including courtship feeding) serves the function of keeping the mates 'cemented' together, it never stops completely. Time spent courting reaches almost prelaying level during the brood period, in both the sexes; presumbly, a preparation for reproducing again and raising another brood without much delay.

Agonistic behaviour tended to be high in both the sexes during the prelaying period. Males guard the females against rival males and females guard their nest-pots against other females. Agonistic behaviour declines in males as well as in females during laying and incubation periods, presumably due to the 'time and energy crisis' caused by the foraging duties of the former and laying and incubation requiremements of the latter. Defense of chicks is another important aspect of female's reproductive strategy, and, as is expected, female agonistic levels increased during brood rearing ($p < .001$).

General discussion and conclusions

Over 90% of all bird species are monogamous. Monogamy with shared parental care (as found in the budgerigar), clearly, is a primitive mating system.[13] The evolution of mating systems and social behaviour is influenced to a large extent by environmental factors such as food distribution and abundance, weather, day, and season length, habitat characteristic, and predation pressures [2,3,15,18]. For instance, Maxson and Oring[13], studied the time budgets of the spotted sandpiper (*Actitis macularia*) and illustrated that due to the selection pressure of particular environmental factors, the species adopted the reproductive strategy of serial polyandry and males assume most or all of the parental duties.

The permanent cohension of pairs in budgerigar must have developed under the unpredictibility of rainfall, creating favourable breeding conditions in the arid central Australia. When rainfall starts, permanent pairs can begin breeding with a minimum delay and so achieve maximum reproductive success in the brief spell propitious for rearing youngs. Similar selection pressure forced sexes in zebra finch *(Poephila guttata*), to maintain permanent cohesion with their mates [1,8,9,10]. Once paired for life, the budgerigar adopted the strategy of large and multiple clutches in order to utilize favourable but brief spells, thereby augmenting the reproductive success. Raising the large clutches in succession, by a 'permanently coupled pair', needs that both the parents should participate in parental duties.[14]

Present study clearly indicates that sexes in budgerigar have complementary strategy and hence the time budgets too are complementary. Females, due to energy consuming large size of clutch and time consuming incubation duties, pass through an 'energy and time crisis' during the course of the breeding cycle. Males do not incubate and alternatively concentrate on foraging, feed the mate, and co-operate in feeding the nestlings. Courtship and courtship feeding/adult food begging never cease

during the course of breeding cycle in budgerigar. This helps in maintaining the pair bond for indefinite length of time.

Extrapolation of these results *ie* captive budgerigar, to the wild one, needs caution. Conditions in aviary are likely to be very artificial. For instance, males in our study proved to be 'hyper-sexual and promiscuous', especially during incubation period, which may not be the case in free ranging wild budgerigar as is suggested by Immelmann [8] for zebra finch (*Poephila guttata*).

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Studies in Animal Behaviour (Ed. Rao & Shetty) Suppl. Bulletin ESI III: 89 - 98 [1984]

Further observations on olfactory signals in the Sambar Deer (Cervus Unicolor)

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Chemical signalling is more useful than other methods of communication as it is effective during night over long distances and in the absence of the signalling animal.[10] The present study is a continuation of our previous studies on various olfactory signals in the Sambar deer, *Cervus unicolor*.[4] It relates various olfactory signals such as allogrooming, self-grooming, allolicking, self-licking, inguinal tickling, sniffing objects, alio-sniffing, flehmen reaction and agonistic behaviour to various social interactions in this aspecies.

Materials and methods

Animals: Sambar deer kept in an open enclosure in the Trivandrum Zoo formed the material for the present study. The enclosure is bounded by walls on all sides except on one side where it is separated from another enclosure by metallic fencing.

In May 1980, during the initial period of the present study, the herd consisted of eleven individuals, six males and five

females of which the youngest was about an year old. Identification of individuals was made on the basis of various marks seen on different parts of their body and the nature of antlers. In order to record the data quickly and easily the males were named as M_1, M_2, M_3, M_4, M_5 and M_6; the females as F_1, F_2, F_3, F_4 and the young as YF.

Behavioural observations were made for a period of four months. Daily observation for two continuous hours were made during any of the periods of 09.00 - 11.00 h, 14.30 - 16.30 h and 16.00 - 18.00 h. selected at random. Data were collected on different types of behaviour of all individuals simultaneously using a check-sheet.

Behavioural Observations: Data on frequencies of self-licking the various body parts in both the sexes of Sambar deer are given in Table 1.

Table 1. Frequencies (mean + SD) of communication behaviour of Sambar deer

Behaviour	*Male*	*Female*
1. Forehead rubbing	98 + 34.4	40.8 + 1.28
2. Inguinal Tickling	111 + 47.4	36.3 + 28.6
3. Sniffing Objects	648 + 169	422 + 82
4. Self Licking		
a. Tarsal	35.5 + 21.3	1.5 + 1.5
b. Meta tarsal	14.5 + 16.8	1.5 + 1.7
c. Caudal	11.7 + 7.8	20.5 + 9.9
d. Digital	7.8 + 7.7	— — —
5. Self Grooming		
a. Tarsal	264.8 + 158.3	44.3 + 11.7
b. Metatarsal	56.3 + 57.6	4.8 + 3.2
c. Caudal	70.5 + 34.9	74 + 46.9
d. Digital	102.3 + 94.9	8 8 + 6.4

(a) **Self-licking :** Licking various parts of their body by curling movements of the tongue was observed in both the sexes. Both the fore and hind-legs, flank, caudal and inguinal zones were subjected for licking at a higher frequency. Rutting stags turned their head towards one side and urinated on their own faces. They then licked and rubbed the regions of face against bricks and then followed females.

(b) **Allolicking :** The members of the herd were observed licking one another especially while reclining side by side. Stags in rut licked the facial parts, caudal region, udder and ventral zones of the female.

(c) **Licking Objects :** Occasionally the stags, does and fawn licked the bricks, stones, posts and trunk of the tree in the enclosure continuously for 25 to 30 minutes.

(d) **Self-grooming :** Grooming differs from licking in that the tongue, teeth and lips were involved. The gentle combings by the teeth were observed between periods of licking. The members of the group groomed themselves while reclining. A number of zones of the fore and hind limbs, flank, ventral, caudal and inguinal regions were groomed at higher frequencies. It was found that the frequency of self-grooming was higher in males than in females.

(e) **Allogrooming :** The individuals of the herd groomed one another occasionally. The major body sites subjected to allogrooming were forehead, antorbital, ear-pinna, neck and flank regions. They groomed mutually while standing or reclining side by side. Allogrooming among females was observed at a higher frequency when compared to males. Mutual grooming was observed between male and male, female and female, male and female and mother and young. Sometimes one individual was groomed simultaneously by two conspecifics. It was also noted that one female persuaded another female to groom her by standing close and pushing.

(f) **Inguinal tickling :** The inguinal region was touched by the tip of the antler in males and by the forehead in females, usually twice or four times in succession. Each such gentle touching was counted as one 'inguinal tickling'. When the horns were shed, the stags used either their forehead or stumps of antlers for this purpose.

The frequencies of 'inguinal tickling' and rubbing of forehead by the individuals are in Table 1. The behaviour of inguinal tickling is common in both the sexes and they show the same frequency between rubbing forehead against objects and hind-hoof, and inguinal tickling.

(g) **Sniffing objects :** The Sambar deer sniffed various objects which had been scent-marked by others. One up and down movement of the snout was counted as one 'sniff'. At times, they stood still against the direction of wind and sniffed the air for some time. Eating, drinking, urination and reclining were done only after sniffing the food, water and ground respectively. During their various activities it was observed that with the slightest disturbance they were made alert, stopped the movements, stood still and sniffed the objects and air several times before starting again.

Table 2 'Allosniffing' in Sambar Deer (Total observation : 140 h)

Animals	Mean + SD	Coefficient variation, %	Level of significance
Male←Male	34+40	11.6	$P>0.05$
Female←Female	11+8.5	74.1	$P>0.05$
Male→Female	188+210	111.8	$P>0.05$
Female→Male	20+20.9	103.2	$P>0.05$
Male→Young	222+201	—	$P>0.05$
Female→Young	31+18	—	$P<0.05$

(h) **Allosniffing**: Sniffing different body sites of conspecifics was also noticed in this species during social interactions (Table 2). Rutting stags sniffed and licked the urino-genital region, face, flank and ventral areas of estrous females several times. Agonistic encounters always commenced by the individuals sniffing each other The herd sniffed the urine and faeces on the ground while moving towards a particular direction in the enclosure.

(i) **Interrelationship of sniffing behaviour in sambar deer**: Average sniffing of objects by males and females during the whole observation period was 648 and 422 times respectively, with the corresponding coefficient of variation of 22.6% and 19.5%. Thus the tendency of sniffing objects was more consistent among females than in males. Male conspecifics sniffed (male→male) at an average frequency of 34 whereas the female conspecifics sniffed (female→female) at an average frequency of 11. The coefficient variation of the data were 11.6% for males and 74.1% for females. So, unlike the behaviour of sniffing objects, males were more consistent than females in sniffing animals of the same sex as indicated by coefficient of variation (Table 2). Further the males have a tendency to sniff the opposite sex at a significantly higher frequency ($p < 0.01$). Males sniffed conspecifics of both the sexes at an average frequency of 222 times and females sniffed 31 times whereas the young (YF) sniffed 27 times. Thus, males were seen to be more active in sniffing conspecifics when compared to the females and the young ($p < 0.01$) of the sambar deer.

(j) **Flehmen reaction**: Flehmen was performed by males in rut, in response to a urinating female. After licking urine on the ground or while it was being voided, the male curled up his upper lip and breathed slowly and deeply with its head held high. The tail was also slightly lifted during this behaviour. The head was sometimes moved slowly up and down or turned

in different directions. The males usually stood still or might follow the female at this time. This kind of sniffing took a longer time than the normal sniffing of objects and air. All adult males responded to female urine except one (M_4) which shed its horns at that time and the young male (M_6). One adult male (M_3) was also found to respond to the urine of the same sex thrice during this study.

(k) **Agonistic encounters**: During agonistic encounters, the stags approached each other, stood face to face, sniffed 10 to 15 times and rubbed their snouts and antlers for about 3 to 5 minutes. They then stoped for a while and again started fighting with their horns until one of them lowered its tail and retreated from the spot. The average frequencies of the winning encounters of the 6 males during the time of observation was 53.66. After the antlers were shed, the bucks sniffed, rubbed their snouts and fought with their raised forelegs.

Discussion

Deposition of an individual's own odour in a home area probably reassures the resident that it is in a familiar place, and can serve as an aid in orientation.[5] Coblentz[2] has listed a number of previous studies showing that the males of most ungulates impregnate the body with the scent of their own urine during breeding season as now observed in Sambar deer.

Most of the observations on allolicking in deer is concerned with the mother and the fawn. The mother uses odours to recognise her own offspring in many species of ungulates.[6] In these species, mothers drive away unfamiliar infants that approach them. Licking the young after parturition by transferring specific pheromones on to the coat of the young form a maternal bond. Markings with the dripping saliva were

sniffed by the conspecifics at a high frequency suggesting that saliva has a role in olfactory signalling.

Saliva which may itself contain specific chemical signals is invariably used to assist in the process of licking. Allolicking of Sambar herd may help its members to convey gustatory signals as well as olfactory cues. Licking the facial region and hind quarters of estrous females by malss probably helps them to recognise such females using olfactory and taste receptors.

Self-grooming may have the same function as self-licking in distributing chemical substances over the body by the process of self marking.[3] Thiessen et al [13] havesug gested that during self-grooming, the animal is ngesting its own secretory products, which may have important feed back effects on the endocrine system in its regulation of the production of the chemical signals and of the behaviour of the animal. In addition to these aspects, the spread of saliva decreases body temperature as a result of evoporation.[14] Allogrooming may result in the transfer of substances from one animal to the other. The high frequency ofself grooming in both the sexes of Sambar deer may help to keep off the ectoparasites from the skin.

The gentle touching of the inguinal region with the tips of the antlers by Sambar stags will probably transfer the secretions from the inguinal glands to the antlers. The antlers in turn are thrashed against the overhead branches or dead twigs. The does rubbed the inguinal region with their foreheads. The possibility of transfer of secretions from the inguinal glands to the forehead and antlers is also suggested by Iyer [9] in spotted deer, *Axis, axis*.

'Sniffing objects' scent-marked by others confirms that these scents have olfactory signals. Mykytowycz [12] attributed functions as recognition of sex, age, social and sexual status to scent-marks in many species of mummals. The determination of the physiological state of females by males is also

possible by means of olfactory cues. Allosniffing appears to have a role in individual recognition among the conspecifics. Discrimination between male yearlings and fawns was indicated by differential rates in sniffing and licking of ant-orbital and forehead secretions.

The function of 'Flehmen' has been shown to be stimulation of the vomeronasal organ.[4] During Flehmen reaction, the estrous status of the female could be detected. Further, to the male, the 'femaleness' is probably not coded in the odour or taste of the urine but in the behaviour of the urinating female, and 'flehmen' is a general testing and not a specific response to urine of estrous female.[11] The male's behavioural response to the odour of the female's urine or anogenital region prior to mounting appears to be the most important biological significance of flehmen.[6] Flehmen in black-tailed deer (*Odocoiieus hemionus columbianus*) serves in 'urinalysis'.[7] Both male and female urine releases flehmen of equal duration although the response of males occurred more frequently in response to female urine in Sambar deer.

Aggessive behaviour in Sambar deer occurs as a variety of types of agonistic encounters near the reclining site. Brown[1] suggested the majority of fighting bouts occur in ungulates when one male invades the territory of another. The males use scent-marks to establish and maintain territories and to identify individuals that invade the territories. The intruder is recognised using odour cues before the fighting specific odours may act to bring the opponents together, and tactile stimuli operate to induce an attack.

Coblentz[2] suggested the 'scent-urination' is used as a cue to indicate age dominance and physical condition in male-male interactions with physical condition being indicated by the metabolic byproducts excreted in the urine, and age dominance by its strong odour. It is thus likely that olfactory cues have a

prominent role in aggressive behaviour and social spacing in Sambar deer.

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Ethological implications in the Ecology of the Tropical Earthworm, Lampito mauritii Kinberg

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The distribution of Earthworms in the soil is dependent on the interaction of factors like soil temperature, moisture, pH, inorganic salts, aeration, texture, herbage, leaf litter, and organic matter. The aggregation of earthworms in certain habitats is known [1,2,6,7] and it may be due to above mentioned factors. It may also be due to characters of the animal such as reproductive potential and defensive powcrs. Hence the present investigation is initiated to study the role of size of the earthworms on their behavioural aggregation.

Methods

Earthworms (n = 390) of 3 different sizes, large (L) > 14 cms in length; medium (M) 8–10 cms and small (S < 6 cms were used. Three sets of experiments of 10 trials each were done. In the first experiment, 15 worms, 5 of each group were used. The second experiment was conducted on six large and six medium worms whereas in the third experiment six medium and six small worms were used. Medium worms alone marked with methylene blue (immersed in 1% aqueous methylene blue for 15 minutes) for identification. Medium size worms in the first experiment are called as M_1 whereas the worms used in second and third experiment are designated as M_2 and M_3 respectively.

In any experiment the worms were placed in a tray 30cm X 22cm) bedded with moist filter paper and observed in light. Drops of water were added in the centre of the group to create habitat instability. The size and number of the earth-worms to leave the group at the end of the second minute and the fifth minute after the addition of water were recorded.

Results and Discussion

In all the experiments, the larger are the first to leave the group, to be followed by the smaller ones (Table). The medium and small worms however, when placed in seperate aggregations move out as rapidly as when large worms are placed independently. That the larger specimens move out first from the group is shown by the behaviour of large and medium animals group in exp. 2 and that of medium and small animals group in exp. 3. When all the three are combined as a group (exp. 1) a significant difference exists between large and small and between medium and small but that between large and medium is not significant. The medium worms behave like the larger animals in the company of small worms (expt 3) and like the smaller animals when grouped with large worms (expt 1 and 2).

This behaviour of medium sized worms is more evident after 5 min rather than after 2 min.

If thigmotaxis were to be operating in the small animals they should remain together when just the small ones are placed independently, but they move out as efficiently as the large worms when placed seperately. It indicated the small worms stay together only during crucial times.

Results indicate that in an aggregation of large, medium and small worms the small ones in the group prefer to "stay together", while the large worms trace a "safety path" by making an initial survey of the surroundings; leaving a trail of

mucus which leads to a rapid escape.[5] This behavior appears to follow a pattern described by Lorenz[4] that "there is not single gregarious species whose individuals do not press together when alarmed, that is, whenever there is a suspicion that a predator is close at hand; the smallest and the most defenseless animals do this the most noticeably, and the adults do not".

Table: Statistical Significance (t) of Data (Ten trials for each group)

GROUP	WORM	MEDIAN VALUES @		SIGNIFICANCE $P < 0.05$
AFTER 2 MINUTES				
1)*	L	3		L, M – NS
	M_1	2		L, S – S
	S	0		M, S – S
2)**	L	3	()	——— S
	M_2	2	()	
3)**	M_3	3	()	——— NS (S at P = 0.1)
	S	2	()	
AFTER 5 MINUTES				
1)*	L	4		L, M – NS
	M_1	4		L, S – S
	S	1		M, S –
2)**	L	5	()	——— NS
	M_2	4	()	
3)**	M_3	6	()	——— S
	S	4	()	

* = 15 earthworms (5 of each size) in each trial

** = 12 earthworms (6 of each size) in each trial

NS = Not significant

S = Significant

@ = No. of worms to leave the group first

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A Pilot study on the behavioural role of the Anal glands of common Indian Mongoose-Herpertes Edwardsi Geoffroy

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Olfactory communications play a salient role in the social inter-actions of many mammalian species. Prominent among diverse sources of body odour in mammals, are the specialised skin glands. Such glands have been reported in 15 of the 19 mammalian orders and many more have been subsequently added to the list. Based on their location in the body, as many as 40 different types can be classified[3]. The olfactory cues of the specialised glandular secretions are usually disseminated by the animals to their immediate environment by scent marking. Relatively very little is known about the role of olfactory signals in social inter–actions of many of the carnivores of our country, especially the Viverridiae. Since the common Indian mongoose *Herpertes edwardsi Geoffroy* is a predator on rodents, lizards, snakes, and small birds, its ethology may yield useful data. Recent investigations on the ethology of common Indian mongoose revealed that these animals rely considerably on olfactory signals for their behavioural interactions[1], The present study was undertaken to elaborate the behavioural role of the anal glands of common Indian mongoose.

Materials and Methods

Mongoose were trapped alive from the fields around Zoological gardens, Trivandrum and brought to the laboratory. The sexes were identified and body weights were recorded. Only healthy adult animals weighing above 800 gms were selected for the study. Animals were housed in standed wire mesh cages 120 x 60 x 60 cms. size, with one or two animals in each cage. Wood shavings were provided for bedding and nest boxes for hiding and sleeping. In the absence of experimental manipulations, normal light conditions and temperature between 20°C – 30°C were provided in the laboratory, Cages were cleaned at regular intervals. Animals were fed on rats, mice, garden lizards and beef and tap water *ad libitum*. Eight adult males and eight adult females were used for this study.

Data on scent marking were collected under both field and captivity conditions. Two different areas, Trivandrum Zoological gardens and Trivandrum Medical Coliege campus were selected for field odservations. A total period of 150 h was spent for field observations. Binoculars were used for observing the animals. Observations under captivity were carried out in two large cages, 150 x 75 x 75 cms size with standed wire mesh on five sides and on one side glass. The cages were provided with nest boxes, stones, logs, tree branches and metal stands. Individuals were identified by clipping part of their hair at specific regions. Observations were made through a small window overlooking both cages without disturbing the animals. Bio-assay experiments were carried out in a large clean cage size 150 x 75 x 75 cms with glass on one side and stranded wire meshes on other sides. Secretions were collected from six adult males and six adult females, after washing the anal area with ethyl alcohol and then rinsed with distilled water. The secretion was then smeared on clean paper weights and were presented to the experimental animals for 20 minutes. The diverse behavioural responses of the animal were recorded.

Results and Discussions

Common Indian mongoose is a social animal living as a family of 3–5 animals. Anal gland region is distinctly demarcated in both sexes by an area of hairless skin, bounded dorsally by the base of the tail and ventrally by the scrotum in the male and vagina in the female. Anal glands consist of a pair of enlarged sacs which open on either side of the anus. The anal glandular region is richly provided with hypertrophied sebaceous glands. Their ducts, either directly open on the anal surface or open into a pair of enlarged vesicles. They collect the secretions of anal glands, a strong smelling brown pasty material, which gives the characteristic mongoose odour. Later they discharge it into the central enlarged vesicles. They void on the anal orifice through small ducts. Normally these ducts are closed. The glands and the vesicles are surrounded by striated muscles. These muscles facilitate the voiding of the contents of the anal sacs through their ducts to the exterior.

It has been observed that mongooses indulge in active scent marking by using anal gland secretions on all conspicuous objects in their territory. Further, males actively anoint different parts of their body with anal gland secretion, especially to palmar and plantar regions, both sides of the upper and lower arms, inner surface of the thigh, ventral surface of the thorax and abdomen and lateral sides of the body by autogrooming, using fore paws and lips. Males also mark their mates with anal gland secretions. Young ones are marked anally by both parents by crawling over them. Generally males mark two to three times more frequently than females. Frequency of anal marking by an alpha male is an average of 16 times per hour, and by the dominant female is an average of 6 times per hour.

Generally 5 types of anal gland scent marking could be observed.

1. Anal dragging :

This is the most common method of anal gland marking. It is usually deployed to mark very low or flat objects. The object is initially sniffed carefully for an average of 5 – 6 seconds. Then the animal assumes a sitting posture with partially spread hind legs and brushes the object with its anal surface and the pelvis is then depressed, until the anus touches the surface with the tail and the hind feet being raised simultaneously. Subsequently, the animal walks forward with small steps dragging its anus on the substratum. Average frequency of anal dragging by a dominant male is 10 per hour and a female is 4 times per hour. Anal dragging is also used in allogrooming.

2. Quadrupedal marking :

This is employed by both males and females to mark substrates or objects at the level of the anal glands. The anal gland is everted partially and the rear end is directed towards the marking objects with the animal taking one or two steps backwards. The tail is elevated and the anal surface is pressed against the object for few seconds without any lateral movement. The anal gland usually closes as soon as contact terminates. The average frequency of quadrupedal marking by a dominant male is 4 times per hour and a dominant female is 6 times per hour.

3. Hand stand marking :

This is deployed to mark vertical and elevated objects such as tree trunks, branches, sleeping boxes etc. In order to perform this, the animal backs up in the air with hind feet, raises the tail vertically. The object is then grasped between the hind feet and the pelvis is then pressed downwards until the anus touches the exact surface to be marked. The anal surface is then pressed across the area or object concerned in a downward direction, the motion being provided by the downward

movement of the hind feet. During this ownward motion, the fore feet perform short abrupt steps forwards and the vertebral column is kept stiff and straight until the anal surface is moved from the object. Though both sexes persumably have the ability to mark by all methods, only males have been seen to use the hand stand position. Normal marking frequency of a dominant male is 6 per hour, and a female is nil.

4. Leg lift marking :

This is another form of anal gland marking. The animal raises the leg nearer to the object until it is slightly higher than the object. Then the body is lowered slightly, so the anal region touches the object's surface. Subsequently the anal surface is actively pressed over the object with the animal slowly moving forwards. Frequency of a dominant male is 8 times per hour and a dominant female is 2 times per hour.

5. Allogrooming :

Apart from marking inanimate objects group members have also been observed to indulge in allogrooming using anal glands. This is performed mainly by anal dragging and by leg lift anal marking. Normally the animals drag the anal region around the pelvis of the conspecific.

Bio-assay experiments reveal that anal gland sectetions are relatively more attractive than any other glandular exudate assayed. In fact they could distinguish between anal gland secretions from different individuals (Table).

When a glass paper weight smeared with the anal gland secretion of a strange male mongoose was placed in a cage occupied by a dominant male, active sniffing occurs followed by intense scent marking, scratching and increased urination together with raising of tail and hind quarters of the body. However the intensity of various scent marking behaviour tends

Table : Mongoose Sniffing Frequency/20 min of glass paper weights smeared with anal gland secretions of different mongoose

Animals	Anal secretion of strange male	Anal secretion of strange female	Anal secretion of known female	Anal secretion of strange male	Own secretion	control
Dominant male	26	17	6	11	3	3
Dominant female	19	5	10	16	4	2
Subordinate male	18	11	11	11	3	2
Subordinate female	13	7	3	8	2	1

to be reduced after about 1½ hours. Further the entire paper weight was impregnated with anal gland sccretion and urine of the resident male.

Similar experiment was repeated exposing the dominant male with the anal gland secretion of a strange adult healthy female and a subordinate male separately. In the first instance no such active threat responses were observed. Further, the dominant male licked the smeared paper weight. However in the latter case there is a considerable increase in the sniffing, preceding scratching, urination and anal dragging could be observed.

A female partner of a fonding pair was isolated and smeared with the anal gland secretion of an alien male conspecific. Later she was placed in the home cage along with her partner. Immediatly the male partner sniffed her intensely at the smeared spot, thrusting its nose into it and followed her around sniffing her whenever she stopped moving. The mate then allomarked her by leg lift anal marking exactly at the spot where the strange anal gland secretion has been smeared.

It has been noted that the anal gland secretion has relatively a longer fade out time, as evidenced by the capacity of the animals to detect the secretion upto 42 days when kept under laboratory condition. However after 48 days they were unable to detect it from control. A dominant male mongoose was able to detect its mark after 18 days when placed in the open field.

The present study suggests that the anal glandular secretions are deployed by mongoose for individual recognition and territorial marking. Similar observations have been reported in other species of mongoose by earlier workers [2,4]. It could also be possible that the anal gland secretions function to identify an area as familiar where as the secretion from a strange mongoose could serve to alert the animal to the presence of a potential intruder of the same species.

Dominant male shows higher frequency of anal gland marking per unit time. It has already been established by histochememical studies as well as histological observations that the dominant male secretes in higher quantities. Ther higher frequency of anal gland marking could possibly be related with the maintanance of dominant status.

Allogrooming with anal gland secretion among conspecifics of the group acts as a bonding mechanism between group members by providing an olfactory stamp, facilitating recognition of diverse family units. Anal rubbing between young ones and adults help to distribute family odours throughout the members. Young ones are marked anally by other group members to prevent them being regarded as prey. Further, family scents facilitate recognition of young ones by the parents, thereby reducing chances of misidentity.

Hence it can be stated that anal gland secretion functions as an olfactory label and facilitates the identification of conspecifics making the mark and the time at which the mark was made. The anal gland secretion has a relatively long fade out time under laboratory condition, while in field condition this is no longer distinguishable after 18 days. Allomarking facilitates a bonding mechanism and indicator of group acceptance between individuals. Once marked, the site where they found is accepted as the animal's own and regularly marked upon.

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Earthworms : Rhythms in oxygen consumption in Lampito Mauritii

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There are no specialised respiratory organs in terrestrial earthworms, the body wall of earthworms however being highly vascularized. Oxygen first dissolves in an aqueous layer on the respiratory surface, which in the earthworm is the whole body surface, from where it passes into the body by diffusion ; the outer surface of the earthworm being kept moist by secretions from the mucous glands. Earthworms are capable of surviving long periods in water with respiratory rate in this medium depe–nding on the partial pressure of dissolved oxygen in the water[2]. Earthworms in trophical areas respire faster than those in tempe-rate regions.

A review of the study of rhythm in oxygen consumption by earthworms has shown omissions with reference to different species, particularly from the tropical region, especially India. The present study deals with the investigation of rhythms in oxygen consumption in *Lampito mauritii*,.

Materials and methods

L. Mauritii were collected from garden soils and were allow-ed to defecate in petri dishes containing moist filter paper for twenty four hrs. Respiratory chambers (n = 5) were set up in

accordance to those described earlier. Each respiratory chamber was coated black and completely covered. Experiments were carried out in unvarying conditions of temperature. One healthy clitellate earthworm was introduced, at a time, in each respiratory chamber and the chamber was filled with water from the reservoir through the inlet tube. Oxygen consumption by each specimen was measured after every two hours for twenty four hours by Winkler's method over a lunar period.

Results :

Results show a diurnal rhythm in oxygen consumption which showed maximal rates around 3 h and around 13 h minimal rates occured at around 21 Hrs. (Table).

Table 1 : Oxygen consumed (ppm) by L. mauritii during different Hours of the day (Average values over a lunar period)

S. No.	Hour of Day	Oxygen consumed (ppm)
1	19 Hr	2.15
2	21 Hr	1.60
3	23 Hr	3.90
4	1 Hr	3.25
5	3 Hr	5.55
6	5 Hr	3.40
7	7 Hr	2.80
8	9 Hr	2.25
9	11 Hr	4.40
10	13 Hr	4.40
11	15 Hr	2.80
12	17 Hr	4.40

Discussion

Respiration rate of animals and plants is not constant throughout the day.[1] Earthworms also show fluctuating respiratory rhythms. Patterns of respiratory rhythm in *L. mauritii* closely follow that of *L terrestris* described by Ralph[3], though the peaks of consumption in *L. mauritii* are slightly advanced when compared to *L. terrestris*. The prominent peak of oxygen consumption in *L. mauritii* around 3 hrs corresponds to the peak locomotor activity observed between 22 hrs and 2 hrs by Zaman & Ismail.[4] The second peak of oxygen consumption also more or less associates with the locomotor activity in *L. mauritii* which occurs around 14 hrs. Though the period of minimal rates of oxygen consumption correspond to *L. terrestris*[3] the overall pattern is almost similar.

Observation strongly suggests that the peak of oxygen consumption in a twenty four hour period in *L. mauritii* strongly associates with its peak activity, thus establishing a rhythm in their activity as well as in oxygen consumption.

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Oxygen consumption of a freshwater Leech, Hirudo Birmanica Circadian Rhythm and Hormonal Involvement

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Introduction

During the past 5 decades, several physiological functions of different invertebrates have been shown to undergo rhythmic fluctuations, some of which can be truly considered as circadian[1,3,9]. Palmer[4] is of the opinion that persistent rhythmic processes are present throughout the living kingdom. These rhythms may be ultradian, diurnal, circadian, tidal or lunar in different life processes of both poikilothermic and homeothermic animals. Persistent rhythms either diurnal and/or circadian in the oxygen consumption of different non-annelidan invertebrates like *Littorina littorea*[17] *Uca pugnax*[6] and *L. irrorata*[18,19] have been evidenced. The neural or neuroendocrine control of circadian rhythms in different physiological activities like locomotion, behaviour and oxygen consumption have been reported exclusively for crustaceans[12,13]. Arechiga[1] has clearly evidenced the occurance of circadian rhythmicity in the activity of nervous system of a crayfish, *Procambarus* and a crab, *Carcinus*.

In comparison with molluscs and crustaceans, studies on the rhythmicity in different physiological phenomena of annelids in general and hirudineans in particular are almost ignored.

Therefore, present study on *H. birmanica* is undertaken to investigate rhythmicity in the oxygen consumption during a 24hr period and possible influence of brain hormones on the rhythmicity.

Material and methods

The leeches, *H. birmanica* were collected from the fresh-water ponds around Aurangabad city. 75 leeches having approximately equal size and weight (5.0 $\pm$ 0.5 g) were selected and divided into five groups, of 15 each as follows :

a. *Normal Controls* : Leeches without any treatment and maintained in freshwater.

b. *Sham Operated Controls* : An incision was made in the head region and brain was exposed but not removed. A thin layer of vaseline was applied to the wound which served as an antibiotic preventing infection.

c *Debrainad* : Brain was removed by making incision in the head region and leeches were maintained for 24 h on the bed of wet filter paper spread over wet mud and wound was covered by thin layer of vaseline.

d. *Debrained injected with distlled water* : 24 h debrained leeches were injected with 50 ul of distilled water 2 h before quantification of O_2 consumption.

e. *Debrained injected with brain water* : 24 h debrained leeches were injected with 40 ul (equivalent to 2 brains/ leech) of brain extract, 2 h before the quantification of oxygen consumption.

Methods for sham operation, debraining, preparation and injections of brain extracts were the same as described earlier.[11] A group of five leeches were shunted to the glass respiratory jars of size 12'' x 4'' having capacity of 1000 ml. Oxygen consumption of leeches from all 5 groups was measured at different

clock hours as illustrated in Fig. 1 using standard Winkler's technique[21]. Three sets, each of 15 leeches, were kept for each group and results are averaged and expressed as ml/g wet weight/hr/L. Temperature (25 ± 0.5°C) and pH (7.1 ± 0.1) of the medium which may affect the oxygen consumption were maintained constant.

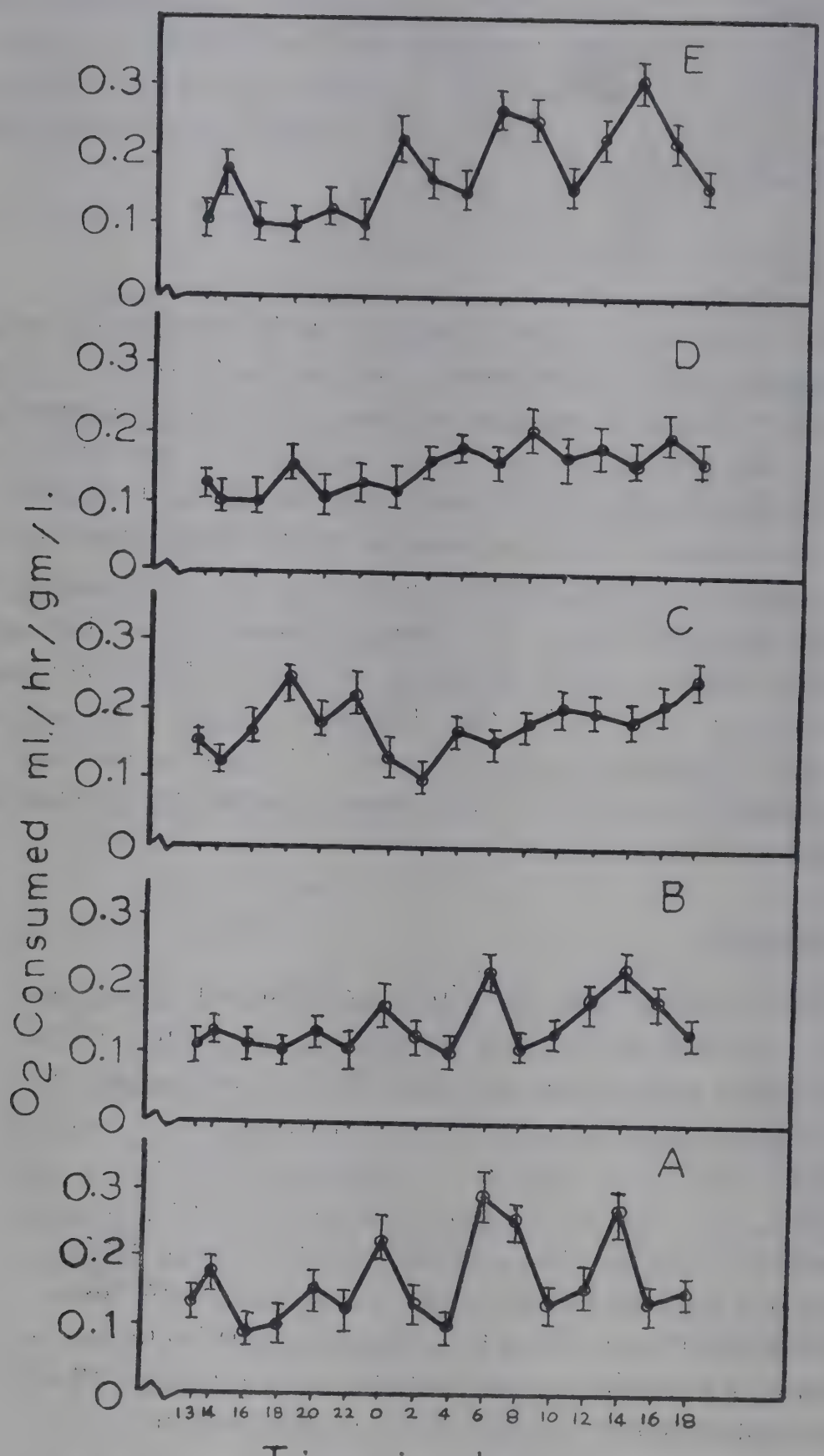
Results

Fig 1 indicates distinct rhythmicity in the rate of oxygen consumption of *H. birmanica*. Normal leaches (Fig. 1A) displayed a rhythmic increase in the rate of oxygen consumption at 14, 24, 06 (Maxima) and again at 14 h. Rate of oxygen consumption reached its lowest value in the early evening at 16 h and again in early morning at 04 h. From the data it is also evident that 24hr brain removal (Fig. 1C) has severely disturbed the rhythmicity of oxygen consumption, but sham operation has no effect except an extinction of peak in oxygen consumption at 14 h. The injection of brain homogenate (Fig. 1E) (2 brains/leech), but not of distilled water (Fig. 1D) has almost restored the disturbed rhythmicity in the brain of excised *H. birmanica*.

Discussion

Daily fluctuations in the environmental parameters are known to induce adaptive changes in metabolic, locomotory, and certain behavioural activities of different invertebrates[1,7,19] A daily activity pattern in the poikilothermic invertebrates would afford a possible explanation for a respiratory rhythms, as activity is the important modifying agent of metabolic activity. Though respiratory rhythm is reported in many non-annelid invertebrates like molluscs[19,22]; crustaceans[1] and insects[7,16], no report is available to our knowledge on these aspects for tropical annelids except on a tropical oligochaete[8], and tropical hirudinean[10]. The rhythmic fluctuations in the oxygen consumption of *H. birmanica*, observed under constant

Fig.1



Circadian rhythmicity in the oxygen consumption of *H. birmanica*. Vertical bars represent the range of variability from mean value.

laboratory conditions, seem to indicate an endogenously entrained clock to detect the hours of the day[9] though the investigation has not totally eliminated exogenous factors the geophysical and cosmic influences. Under the conditions of investigation the rate of oxygen consumption of normal leeches was at its highest peak in early morning at 06 a.m. with considerable high rates of oxygen consumption at midnight (24 h) and afternoon (14 h) also. A minima in the rate of oxygen consumption was at early evening (16 h) and morning (04 h). Nearly similar trend was reported by Hanumante[8] in the megascolecid worm, *P. excavatus*.

The functional organisation underlying the circadian rhythmicity is, however, largely unknown. The mass of evidence of rhythmicity considerably overweighs the knowledge of physiogical mechanisms supporting the rhythmicity. The basic questions on the localization and mode of operation of the circadian pacemaker, the transducers and pathways coupling the endogenous oscillators to the environment, and the internal coupling of the putative "Circadian clock" to the structures displaying the overt rhythmicity are partially answered[1]. The important channel conveying information about rhythmicity from the clock to the effectors is the axonal pathway, as has been suggested for the locomotory rhythms of insects[5] and oligochaete worms[4]. It was observed in *H birmanica* that excision of brain for 24 h caused severe disturbance to the rhythmicity in oxygen consumption. There is no report either supporting or contradicting these results in annelids. However in crustaceans a supression or profound alterations in various circadian rhythms of activities after eyestalk, the most extensively studied among the organs, thought to contain the "circadian clock" in crustaceans, was excised. All the structures displaying circadian rhythmicity are also known to respond to eyestalk extracts[1,3]. In contrast, Webb *et al.*[20] have reported that rhythms of oxygen consumption persist in *Uca* even after eyestalk ablation. In the present investigation brain extirpated *H. birmanica* injected with

brain homogenates which showed similar oscillations in the magnitudes of oxygen consumption as the controls did indicate that the chemical substance, probably neurohormones secreted in the brain may be responsible for rhythmicity of oxygen consumption of *H. birmanica*. Occurance of two types of neurosecretory cells (A and B) in the brain of *H. birmanica* is already indicated by our unpublished data. It supports earlier reports[2]. It is quite possible that the substance responsible in restoring the rhythmicity may be a proteinaceous neurohormone released through axons. Similar but more precise report[2] on crustaceans showed that the substance responsible for the effects on neural elements was a peptide of a low molecular weight, stored in the neurosecretory endings of the sinus gland from where it can be released *in vitro* to maintain rhythmicity.

The involvement of brain (supra–oesophageal ganglion) in circadian rhythms of crustaceans also is known.[1] Further the supra-oesophageal ganglion, is also shown to be involved in the control of circadian rhythm of locomotion in crustaceans. It indicated that there is interaction among the various oscillators and possibly a multifactorial control[15] of any circadian rhythm.

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Circadian Rhythm in Oxygen Consumption in some Indian Air-Breathing Teleosts.

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Recent studies on air-breathing fishes have shown that they are adapted to varying degrees of bimodal gas exchange [2,9,3,7]. Little information is available on circadian rhythm in their oxygen consumption.[8] The present report is a study of rhythms in three species of air-breathing teleostean fishes.

Materials & Methods

Adult *Anabas testudineous* (Bloch) (Anabantidae) (58.0 ± 3 g), *Clarias batrachua* (Linn) (Claridae) (97.0 ± 2 g) and *Channa punctatus* (Bloch) (Channidae) (67.5 ± 3 g) collected from swamps of North Bihar in September, 1982, were maintained in large glass aquaria with running water. They were fed goat liver on alternate days for 15 days, and were fasted 12 hours before experiments. The fishes were acclamatized to the experimental conditions in the respirometer overnight.

A fish was placed in glass respirometer[4] containing 3 litre fresh tap water with initial dissolved oxygen content, of 5.8 mg/l and pH, 7.3 and 1 litre of air. The fish had free access to air through a small semicircular hole (5 cm. diameter) in a disc float of thermocol that separated the water-air interphase of the

respirometer. KOH in petridish placed on the float absorbed CO_2. The respirometer was placed in a constant temperature waterbath. All experiments were carried out at 28.3 ± 1° C in the autumn season in an air–conditioned room with the light on for 24 hours.

Aerial respiration was studied with the help of a manometer.[1] Aquatic O_2 uptake was calculated from the difference between the O_2 levels of the ambient water in the respirometer before and after the experiment and the amount of water in the respirometer by Winkler's method.[11]

Experimental runs of 1 h thrice in each wt. group of fishes were started after the fish had properly adjusted to the respirometer. "Paired tests" were employed to test the level of significance of the differences between the sample means of the bimodal oxygen uptake during various periods of the day. Equivalent energy utilization was also estimated by applying an oxy–caloric equivalent of 4.8 K cal per litre of oxygen.

Results

Values for oxygen consumption simultaneously from air and water of *Anabas*, *Clarias* and *Channa* have been summarised in table–1, a, b, & c.

Anabas Testudineous

Oxygen uptake through the accessory respiratory organs was at its peak (64.6 mg/kg/h) in the early hours of the night, with a secondary high (52.6 mg/kg/h) in the mid–day period. The difference between the early night and mid-day periods was statistically significant ($P < 0.001$).

The maximum oxygen consumption from water was (33.6 mg/kg/h) during the dawn (4–6 h) and the minimum (15.5 mg/kg/h), in the mid–day (12–14 h) period.

Table–1. Oxygen uptake during bimodal breathing at different periods of the day (mean ± S.E.)

Time (h)	No. of fishes	VO_2 (Air) mg/kg/h	VO_2 (Water) (mg/kg/h)	VO_2 (Total) (mg/kg/h)	VO_2 (Air) %	VO_2 (Water) %
(a) A testudineus						
0–2 (Night)	6	44.6±0.04	23.0±0.04	67.6±0 02	66.0	34.0
4–6 (Dawn)	6	52.8±0.07	33.6±0.04	86.2±0.12	61 0	39.0
8–10 (Morning)	6	49.3±0.14	21.2±0.03	70.5±0.37	69.9	30.1
12–14 (Midday)	6	13.3±0.08	15.5±0.00	28 8±0.32	46.1	53.9
16–18 (Dusk)	6	50.0±0.21	25.9±0.06	76.7±0.42	66.3	33.7
20–22 (Early Night)	6	64.6±0.20	23.3±0.15	87.9±0.14	77.5	22.5
(b) C. batrachus						
0–2 (Night)	6	33.1±0.00	52.6±0.00	85.7±0.00	38.6	61.4
4–6 (Dawn)	6	45.7±0.13	50.5 0.06	96.2±0.30	48.0	52.0
8-10 (Morning)	6	29.7±0.02	48.9±0.01	78.6±0.05	37.6	62.4
12–14 (Midday)	6	13.1±0.06	56.5±0.02	69.6±0.66	18.8	81.2
16–18 (Dusk)	6	33.9±0.02	52.9±0.06	86.8±0.06	39.0	61.0
20–22 (Early Night)	6	47.6±0.21	62.9±0.25	110.5±0.09	43.1	56.9
(c) C Punctatus						
0–2 (Night)	6	46.8±0.09	18.5±0.10	65 3±0.24	71.7	28.3
4–6 (Dawn)	6	57.1±0.12	29.9±0.07	87.0±0.24	65.6	34.4
8–10 (Morning)	6	54.2±0.09	25.2±0.06	79.4±0.20	68.2	31.8
12–14 (Midday)	6	17.3±0.36	36 7±0.38	54.0±0.05	32.1	67.9
16–18 (Dusk)	6	53.6±0.09	24.4±0.10	78.0±0.30	68.7	31.3
20–22 (Early Night)	6	44.4±0.06	20.0±0.05	64.4±0 08	69.0	31.0

Clarias batrachus

While the maximum O_2 consumption (47.6 mg/kg/h) occured in the 20–22 h period, with a second peak at 4–6 h, the minimum (13.1 mg/kg/h) was observed at 12–14 h.

Oxygen consumption from water was higher in *Clarias* than in *Anabas* and *Channa*. The highest value (62.9 mg/kg/h) was seen in the 20–22 h period and the lowest (49.0 mg/kg/h) at 9–10 h period.

The highest total O_2 consumption was 110.5 mg/kg/h at 20–22 h with a secondary high (96.2 mg/kg/h) at 4–6 h, and lowest (69.6 mg/kg/h) in the 12–14 h period. A maximum of 48% of total O_2 was taken up from air in the 4–6 h period and a maximum of 81% of total O_2 was consumed from water, in the 12–14 h period.

Channa punctatus

The period of highest O_2 uptake (57.1 mg/kg/h)from air was observed in the 4–6 h period with a secondary peak in the evening (8–10 h) and lowest uptake (17.3 mg/kg/h) at 12–14 h period.

The peak value of O_2 consumption (37.7 mg/kg/h) from water occured at 12–14 h and in this respect *Channa* differed from *Anabas* and *Clarias*. The lowest, around 19 mg/kg/h, were recorded at night (22–24 h).

The highest values of total O_2 cosumption (87.0 mg/kg/ h) was observed at 4–6 h period, with another peak value (78.0 mg/kg/h) at 16–18 h, and the lowest value of 54 mg/kg/h at 12–14 h. Unlike *Anabas*, *Channa* depends more on air–breathing than *Clarias*. Most of oxygen that was derived through air–breathing was 72% in the 0–2 h period, and from water, 68% in the 12–14 h period.

When estimates of equivalent energy utilization have been made by applying the oxycaloric equivalent of 4.8 K. cal per litre of oxygen consumed, *Anabas* (5.58 K. cal/kg/day) and *Channa* (/5.797 K. cal/kg/day) gave almost the same values of energy expenditure. *Clarias* gave a slightly greater value of 7.06 K. cal/kg/day.

Discussion

The present study shows that the metabolic rate in *Anabas*, *Clarias* and *Channa* vary in different periods of the day, indicating a clear circadian rhythm in their metabolism. This comparative study on metabolic rate of these fishes have shown that the maximum oxygen is consumed at dawn (4–6 h). The minimum oxygen consumption is at mid-day (12–14 h). The variation of their metabolic rate at different periods of the day may be due to their different modes of breathing. *Anabas* takes 70–77% of its total oxygen demand from air during the morning hours and early part of the night. *Channa* depends more on air-breathing (68–71.7%) in the morning and night hours. *Clarias* takes more air-gulps (48%) in the early morning hours than any other period of the day. Curiously, all of them prefer to remain mostly under water in the mid-day hours.

A detailed field observations made by the present author reveal the fact that air-breathing fishes are most active in nature in the morning hours of the day when they move about in search of prey. In the night also many of them come out of their micro-habitats below the coverage of macro-vegetation to open waters. In the night hours some specimens of *Channa gachua* and *Channa punctatus* from the open shallow areas of the swamp were collected easily with the help of torch light. They appeared to shun bright light and many of them take shelter in the shade amongst the coverage of floating plants like *Eichhornia crassipes* and *Euryale ferox*. There is complete oxygen depletion in the late night and early hours of dawn (DO, 1.8 mg/l to nil and CO_2, 24 to 34 my/l). In nature it

seems that all the three air-breathing fishes consume more oxygen from water than air during mid-day hours when, O_2 content of water is high (8.54 mg/l) and free CO_2 is low (9 mg/l) due to the photosynthetic activity of the phytoplankton and other aquatic vegetation. Ultsch[10] has made a detailed study of the micro-habitats of water hyacinth communities, where he found several species of the air-breathing fishes.

The metabolic rhythm of fishes may be related with their general activities such as food capture and consumption, play, resting and sleep. Further it seems that the circadian rhythm of metabolism in poikilotherm animals closely inter-related with the diurnal fluctuation of dissolved gases of the environment. The dependence upon aerial breathing of these fishes utilizing bimodal gas exchange (air and water) can be evaluated as a function of time of day.[4]

In the respirometer, the fish did not perform any such activities as mentioned above and the environment also remained stable. Inspite of this the fishes consistently showed circadian rhythm in their metabolism. It seems that this rhythm has become an inherent property of their system.

Acknowledgement

I would like to express our special gratitude to Dr. J. S. Datta Munshi, Professor and Head of P. G. Zoology. Bhagalpur University, for laboratory facilities and his critical remarks and to Professor Pierre Dejours, Laboratoire de le Recherche Scientifique, Strasbourg, France, for going through the manuscript and valuable suggestions. The work was supported by U. G. C., New Delhi.

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Field studies on Eco-Behaviour of Pteropus Giganteus Brunnich (Megachiroptera)

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The *Pteropus* is the orchard's pest, known for dispersal of seeds, and dwelling on trees. It exhibits sedentary habit. They roost on large banyan trees, different species of figs, feathery tamarinds, and bamboo clumps etc., in small or large colonies.[6] Earlier workers have studied certain aspects of biology and behaviour.[2,5] Field eco-behaviour studies made on a colony of *Pteropus giganteus* are reported here.

Methodology

A total counts of 16 on primary roost "A" were taken once a week in early hours of the morning before disperal, spreading over winter and early summer of 1983 by binoculars. As roosting trees (peepal) are large and deciduous, counting was done easily covering bats of entire roost from 3 triangular positions. Temperature and relative humidity were recorded at the time of numerical studies by using thermometer and hair hygrometer. Total counts were also taken in noon and evening. Similarly 16 total counts of bats on roosting site "B" and 5 total counts on "C" were recorded depending on the frequency of occurence.

Intermittent observations were made in the field from dawn to dusk and activities of bats were recorded (Temperature and R.H. were also recorded at the time of observations). Numerical studies were made on transients visiting roost "A & "B" by total counts to know the relative abundance of bats on different roosts.

Fragmentation index was worked out to know the suitabliity of the roosts by measuring the distance between A & B, B & C and A & C, by using tape.

Fragmentation index was calculated as follows :

$$F.I. = \frac{D.F. - D.N.}{D.F.} = \frac{935' - 300'}{935'} = \frac{635'}{935'} = 0.67$$

D. F. = Distance between 2 distant roosting sites.

D. N. = Distance between 2 nearest roosting sites.

F. I. = Fragmentation index.

Fragmentation index ranges from 0 to 1. Higher the index more deleterious is the habitat for existence of larger animals. Since the F.I. was 0.67 the habitats were not unsuitable for bats to rest and sleep though physical barriers existed in between the successive habitats. Probably to avoid physical barriers like a series of human dwellings and light poles, the bats moved in a curved path in order to reach "B" during dispersal. During flights these bats had trees as landmarks and flew over them.

The study spot consisted of 3 roosting sites in Bangalore south. These were designated as A, B & C for the sake of convenience. All the roosting sites were located on elevated area.

Roost A consists of a group of four high wide spreading, large peepal trees *(Ficus religiosa)* in a line. This roosting site is located in a temple area visited by people during morning and evening only. Roost A is a secured habitat located away from busy area and traffic disturbances. Field observations revealed

that this roost formed the primary roost or permanent abode. The flying foxes have colonised in roost A inspite of presence of hundreds of trees around that area including banyan and tamarind trees. The bats showed 100% frequency of occurence on A.

Roost B consists of two wide spread large Peepal trees located side by side again in a temple area in Bangalore south and at a distance of 720 ft from A. When compared to other shade trees on road side, Roost B is located away from traffic and bats from A occupied B regularly either to overcome adverse conditions in A or for rest before departure for foraging activities. Hence roost "B" formed the secondary habitat or alternate roost. The bats showed 100% frequency of occurence on B.

Roost C consists of a wide spread large neem or margosa tree (*Azadirachta indica*) located in a school nearer to roost B, (300') than to A (935'). Bats visited and settled occasionally on site C. The bats exhibited 31% of frequency of occurence on roost C. Hence C could be regarded as tertiary roost of occasional importance.

Thus the three roosting sites formed a triangle ABC, where AB=720', AC=935' and BC=300'. Large number of trees are available on side AB and side BC, but not along AC, where mostly houses are present. The bats settled during day on primary and secondary sites, thus exhibiting limited distribution range probably due to habitat specificity. The occassional site is of survival value to overcome adverse conditions and wrangling. According to Neuweiler[5] the colony of bats has atleast one specific evasion area. But, our field observations revealed that additional roost not only form evasion areas but also alternate and occasional dwellings.

Transients are animals which visited the habitat of bats occassionally. The counts of transients were made randomly. They were found mostly in sites A and B occasionally in site C.

Results and Discussion

Studies on population by total counts revealed that the colony on primary roost consisted of 850 to 1,350 bats as shown in Table 1.

Comparison of the numerical studies made on bats in 3 roosting sites A, B, C, revealed that the measures of central tendency (Mean, medium, modal class & mode) were in the descending order. (A>B>C). Median indicated the habitat preferendum of the bats in the descending order of A, B, C. In all 3 habitats positively skewed distribution was observed. S.K. Coeff–skewness of B and C bats studied showed + 0 73 and + 0.934 respectively. Relative frequency of occurence, relative abundance and number of hours spent by bats on sites and roost for homing helpedus to decide A as primary roost, B & C as secondary and tertiary roosts respectively.

Dispersal of bats from primary to secondary roost occured under adverse condition. Various causes for dispersal from A were smoke (due to burning of dry leaves and seeds like parthenium below or near the roost) causing air pollution and suffocation to bats, human interferences (catching bats, stoning and bursting crackers), interference of non-human primates like *Bonnet Macaque* (shaking of branches rapidly & causing mechanical distrurbances).

Coeffecient of variation worked out for different roosting sites were as follows :—

Habitat A = 14.39

Habitat B = 91.78

Habitat C = 28.43

B was variable to C by 3 times and to A by 6.5 times. C was variable to A by 2 times. A was less variable than other additional roosts.

Table : 1 Study of Pteropus giganteus on different roosting sites in Bangalore South during Winter and early Summer 1983

		ROOSTING SITES		
		Primary Roost of 4 peepal Trees A	Secondary Roost of 2 peepal Trees B	Tertiary Roost of a neem Tree C
1.	Median	1090	117	70
2.	Range of bats resting after dispersal From A	Nil	595	45
3.	Standard deviation (S.D)	164.1	164.3	18.2
4.	Percentage of mean dispersal for overcoming adverse conditions and to rest on other habitats	21.3% from A to B	26.3% from B to C	Nil
5.	Number of hours spent on roosting sites	more than 13 h	$\frac{1}{2}$ h to 13 h	$\frac{1}{2}$ h to $2\frac{1}{2}$ h
6.	Relative abundance	High	Low	Very Low
7.	Habitat preferendum	A is preferred to B and C B is preferred to C.		

Table 2 : Diurnal Activities of Pteropus Giganteus

	Period of observations	Temperature in °C at the time of observation	R. H. in % at the time of observation	Number of Activities
n = 9	Early hours of morning after arrival			Bats exhibit 13 types of activities without sleeping.
Mean		24.6° C	54%	1. Late arriving 2. Flight with slow wing beats 3. Settling on roost 4. Local shift or displacements 5. Self-grooming 6. Licking 7. Wrangling for sleeping sites 8. Jerking movements on diageotropic branches 9. Ascent & descent of negatively geotropic branches 10. Loud calls while wrangling 11. Wing spreading 12. Disloding of earlier arrivals by late comers 13. Driving & chasing
Range		19 to 33.25	24–82	

n=8	Noon			Bats exhibit 5 types of activities mainly including resting & sleeping.
Mean		33°C	25.62%	1. Partial unfolding and flickering wings side ways
Range		3.15 to 35	17.5 to 33.5	2. Intermittent fanning 3. Unfolding both wings and covering body 4. Resting & wing flickering 5. Sleeping with folded wings (Noise less)
n=9	Evening before departure			Bats exhibit 9 types of activities without sleeping.
Mean		29.33°C	28.5%	1. Wake up from sleep
Range		24.75 to 34.25	20 to 39.5	2. Flight with slow wing beats 3. Flying 4. Settling on roost several times 5. Displacement or local shifts 6. Ascent & descent of negatively geotropic branches 7. Self grooming 8. Unfolding wings repeatedly 9. Departure

n = number of observations.

The activities observed are shown in Table II

The bats woke up in the evening before sunset and remained active till the early hours of the next morning, They were highly active before departure for foraging activities from primary and secondary roosts. The colony broke up into 5 to 6 batches and moved in droves for some distance after departure. Then each steered its own way. During winter, departure of majority of bats in the colony took place after sunset between 6.40 to 7.00 p.m. and some late departures left the roost between 7.30 to 7.45 p.m. But in summer majority of bats departed the roosts after sunset between 7 to 7-20 p.m. Late departures left the roosts between 7.45 to 8.00 p.m. Before sunrise most of the bats arrived to the primary roost. But, several late arrivals reached the roost between 6.00 and 6.20 a.m., during winter and 5-45 to 6.00 a.m. during summer. During arrival to the primary roost the bats passed by secondary and tertiary roosts. But, during departure 45 to 75 (mean=60) bats left primary roost early and settled on secondary roost for more than half an hour and then left for feeding.

Dispersal of bats, from A to B, from B to C and retreat from C to B or A roost or from B to A roost took place in droves. Usually each batch took 2 to 12 minutes (mean= 6.4 min.) to rest on secondary roost. The bats reached B in 4 to 6 batches or droves with a mean of 5 batches or droves from A to avoid adverse conditions.

They were highly active in cloudy weather when relative humidity was high (>76%). They also became active before and after showers of rain. They dispersed from A in droves moved up to B and C, then they turned to A via B. They flew with slow wing beats near each roost. Wrangling and shrill calls were not observed. This type of dipersal probably due to climatic conditions could be easily distinguished from dispersal of bats from A to overcome unfavourable conditions.

Intra specific competitions included wrangling for resting and sleeping places, dislodging of earlier arrivals by late comers for suitable sleeping places, striking rivals by wing claws and chasing rivals. They used wing claws for offence and defence of the body. Intra specific fights were accompanied by their shril calls.

The transients were crows, sparrows, Indian palm squirrel, bonnet monkey. They probably visited site A and B because they were not disturbed by humans and also not by bats which are nocturnal.

Conclusion

Displacement, effective dispersal, habitat preferendum and other related activities showed diurnal rhythms in bats on roosting sites. High atmospheric humidity caused an activity which is different from normal activity.

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Synchronised Shifting of Liver Glycogen and ATPase Activity Under Varied Light Regimen.

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Circadian rhythmicity in hepatic glycogen has been reported in many species studied[2] with *ad libitum* feeding. The rhythmic fluctuations in the energy metabolites or energy linked metabolic enzymes are known to influence the behaviour of the animal.[1] The biological oxidation of tricarboxylic acid cycle intermediates and energy degrading system in rats were also shown to be associated with their locomotor activity.[2] The present study is directed to demonstrate the occurrence of a rhythmic variation in liver glycogen and the chief energy linked enzyme adenosine triphosphatase (ATPase) activity in the albino rats, *Rattus norvegicus albinus* under varied photoperiodic conditions.

Materials & Methods

Breeding and culturing of albino rats *Rattus norvegicus albinus* were carried out in the culture room under controlled laboratory conditions (26°C, 80% RH) feeding *ad libitum* on balanced diet. About 120 male albino rats of three months age were experimented. Under normal (LD 12:12) reversed (DL 12:12) and constant light (LL 24 Hrs) as well as in constant dark (DD 24 hrs), different sets of rats were acclimatized. During dark period ceiling lights were put off in the experimental periodicity room, shielded flash light being used for

the few seconds of cage removal. For LL and DL conditions a light source was arranged 380 cm above the animal cage.

The liver glucose and glycogen were determined by conventional method and ATPase activity was estimated by standard method under normal and artificial day and night conditions.

Results & Discussion

The data depicted in the figure 1 and 2 show the actual synchronization time of the liver glycogen, and

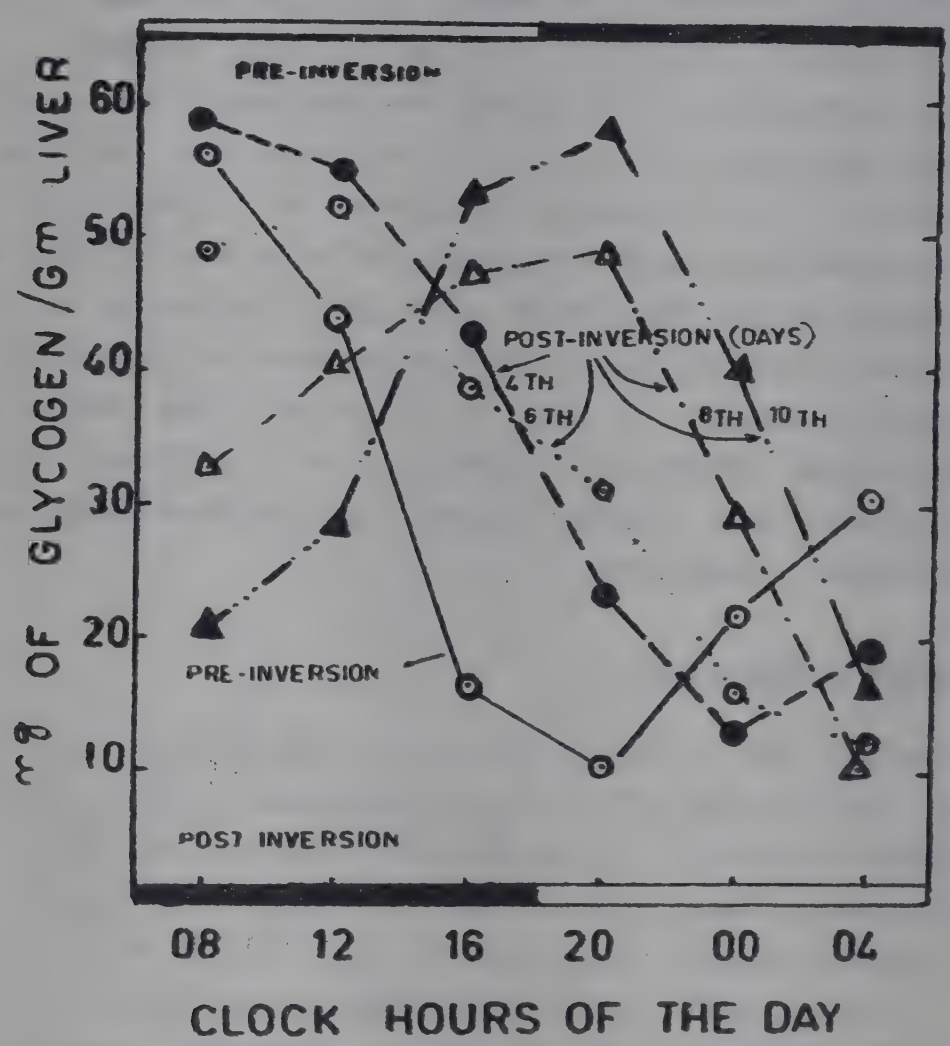

Fig. 1 : Glycogen rhythmicity in the liver of albino rat, *Rattus norvegicus* under LD (normal) and DL (reversed) light conditions. The values are average of four individual experiments.

ATPase activity rhythms respectively, revealing a clear scrutiny of the time course of phase shift. From the data, it was also

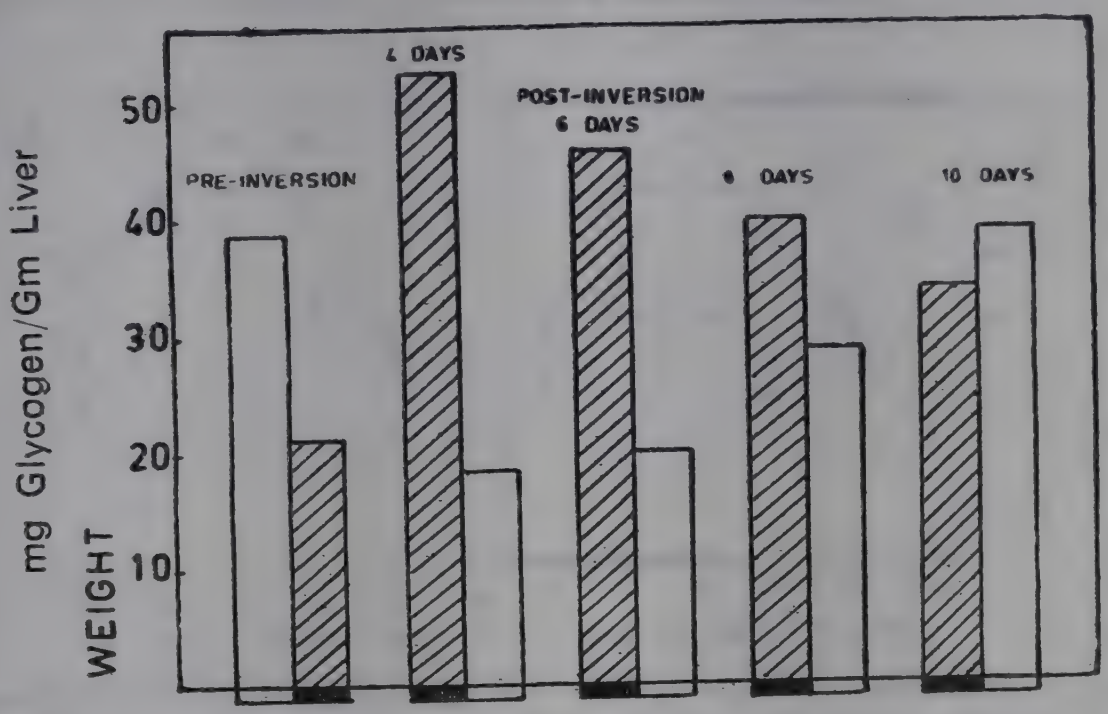

Fig. 2 : Average level of hepatic glycogen during 20-00 to 04-00 h and 08-00 to 10-00 h under normal and reversed light regimens.

known that on the 10th day under reversed light regimen, the inversion of rhythm is far advanced. If one would judge the 08.00 h value, the preinversion maximum, the shift is as yet incomplete, and this value had not yet become minimum on day 10, but it was minimal on day 15. However, the exact definition of inversion time in hours rather than in days seems beyond the scope of this data and would imply an unwarranted degree of precision.

On the fifth day after light inversion (DL 12:12) the peak period and the trough of the glycogen and blood glucose (Figure 1) and ATPase activity (Figure 3) rhythm appears to be shifted by about 4 h, where as after 5 more days further inversion by 6 hours and on 15th day complete displacement by 8 hours showing a shift by 180 degrees out of phase with normal has occurred. These results suggest an initial slow rate of phase shifting followed by a relatively faster shift.

Under constant conditions of light (LL) and dark (DD) the rhythmic trend in glycogen, glucose and energy linked enzyme ATPase level showed their entrainment (figure 3). However,

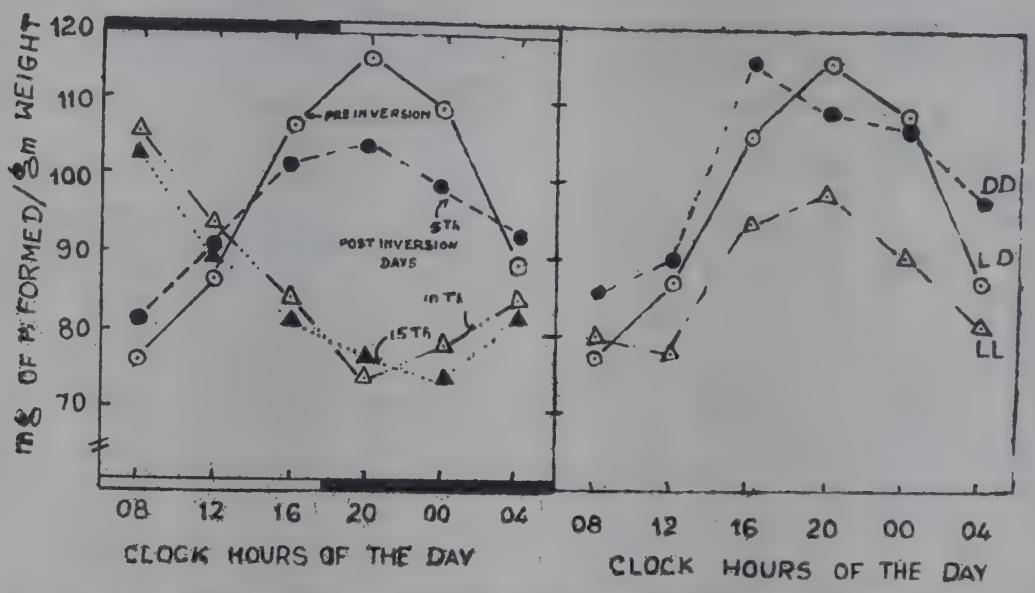

Fig. 3: Rhythmic ATPase activity in the liver of the albino rat, *Rattus norvegicus* under normal (LD), reversed (DL), continuous light (LL) and dark (DD) conditions. The enzyme activity was expressed as mg of Pi formed/gm wet weight of tissue. The values are average of four individual experiments.

an "advanced" phase shift under DD and a "delayed" shift under LL over LD animals were registered in ATPase activity, Similarly the liver glycogen and blood glucose showed double peak periods under LL condition and a delayed phase shift of 4 hours for glycogen and an advancement for blood glucose under DD were observed. Such phase shifts of about 4 hours are within the limits of the period range viz., 24 hours of either the metabolites or the enzymatic activity.[3] However, this study indicates the interdependency of the metabolite and the related enzyme under varied photoperiodisms. It is probable that enhanced ATPase activity during dark hours is related to the overt locomotor activity of nocturnal rat. The entrainment of rhythm under constant laboratory conditions (LL or DD) reflects its endogeneity although the persistence of rhythm does not in itself provide a rigorous proof. However, this persistency of rhythm under different synchronized light

regimens is in support of the hypothesis that "all organisms possess an innate biological clock".[4] But the innate physiological clocks have a phase susceptibility inspite of endogeneity indicating its "Zeitgeber" action under artificial day and nights envisaging an adaptive value for the nocturnal habit of rat.

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Physiological Mechanisms and Behavioural Patterns During "Environmental Stress" and "Environmental Adaptation".

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Many poikilothermic animals respond to changes in environmental temperature and pollution by alterations in metabolic rate. When poikilothermic animals are subjected to such environmental change and when the process of acclimation is complete, one can differentiate between "environmental stress" and "environmental adaptation".[4,3,9] Adenine nucleotides play a special role in the regulation of the metabolic changes, hence the adenylate-system is to be considered as a standard. The energy change in this system according to Atkinson *et al*[2] represents a coefficient of the metabolic function of the three nucleotides. (ATP, ADP and AMP). In the present study, therefore measure of nucleotides has been used to differentiate between "adaptation" and "stress".

Material and Methods:

1. *Differentiation of "temperature stress" and "temperature-adaptation".*

To differentiate the temperature-adaptation from temperature-stress phenomenon, two groups of the fish, Golden orb,

Idus idus were used. One group was subjected to a slow temperature change at the rate of 1^0C/2 days and the other group was subjected to a rapid change of temperature change at the rate of 1^0C/h from 10^0 to 20^0C. The following parameters were measured.

a) Time course of oxygen consumption of the whole fish was measured according to the improved Winkler's method.[8]

b) Time course of ATP, ADP, AMP concentrations in muscle and brain were estimated as per the method given by Bergneyer[5] and Gronow.[7] The energy charge which is equivalent to ATP + $\frac{1}{2}$ ADP/ATP + ADP + AMP is calculated as per Atkinson.[2]

2. *Differentiation of "pollution - stress" & "pollution-adaptation"*

The common carps *Cyprirus carpio* were used in two different batches. One batch of fish was subjected to a slow malathion change at the rate of 0.1 ppm/2 days and the other was subjected to a rapid malathion change of 0.1 ppm/h and the following parameters were masured.

a) Time course of oxygen consumption of the whole fish was measured according the improved Winklers method.[9] R B C count was done using haemocytometer.

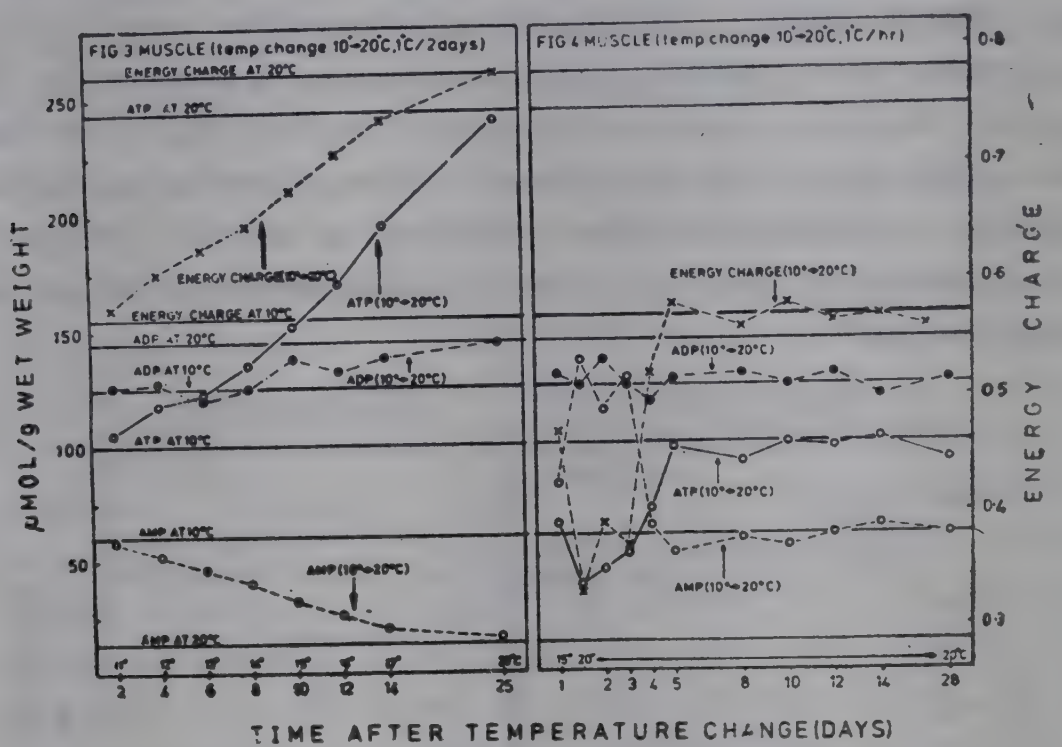
b) Respiratory behaviour of the fish was studied by measuring the opercular activity (time taken for ten opercular movements).

c) Food intake behaviour of the fish was studied through the qualitative analysis of the gut contents.

d) Growth of the fish was studied by measuring the length of the fish through camera lucida.

Results and Discussion

The results showed that animals under "stress" are different from animals "adapted" to on environmental change and hence all embracing earlier concept of adaptation [1] is obsolete.



Figures 1 & 2: Concentrations of ATP, ADP, AMP and energy change in the dorsal muscle of the fish, *Idus, idus* subjected to a slow temperature change from 10° – 20°C, at the rate of 1°C/2 days (Fig. 3) and to a rapid temperature change from 10° – 20°C, at the rate of 1°C/h (Fig. 4). Each point is a pool of the dorsal muscle from 15 to 20 fishes and a mean of 6 estimations.

In the figures 1 and 2 the straight horizontal lines represent the levels of the nucleotide cones and energy charge in the dorsal muscle of the fish at two different adaptation temperatures of 10 and 20°C. The two temperatures (10 and 20°C) are with in the range of temperature (5°–25°C) to which fish are usually exposed. In order to differentiate the adaptation process from-stress phenomena, the 10°C adapted fishes are readapted to either a slow rise of temperature of 1°C/2 days or quick rise of temperature of 1°C/h from 10 to 20°C. The fish subjected

to a slow temperature change displayed the filling up processes with ATP and reached the orginal control levels of the nucleotides and energy charge. In contract filling up processes with ATP was not observed in the muscle of the fish subjected to quick temperature change. The control level was not achieved even after 4 weeks. The muscle established the new levels of nucleotide cones under continuous stress operating on the animal. A similar pattern of changes in nucleotides of the brain also of the same fish was shown. The pattern of nucleotide changes substantiated earlier evidences of similar changes in lactate–pyruvate ratio [7], O_2 consumption pattern of whole fish and its tissue [10].

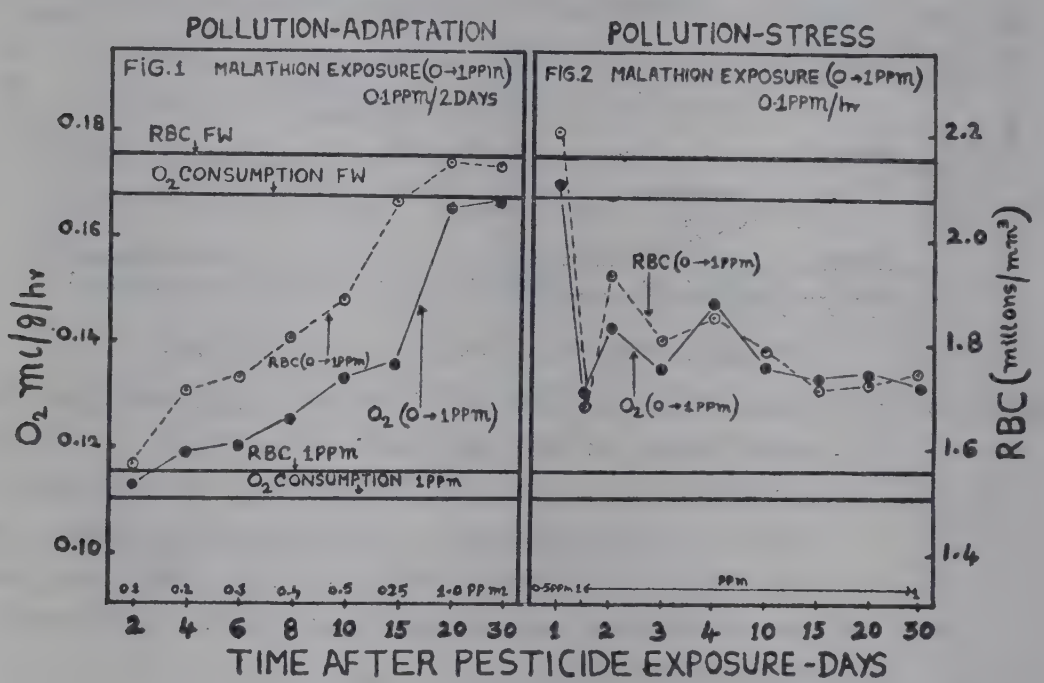


Fig. 3: The rate of oxygen consumption (O_2ml/g/h) and the RBC number (millions/mm3) in common Carp, *Cyprinus carpio* subjected to a slow sub-lethal (1 ppm) malathion change from 0.1ppm, at the rate of 0.1ppm/2 days. Each point is a mean of 10 individual measurements.

Fig. 4: The rate of oxygen consumption (0_2ml/g/h) and the RBC number (millions/mm3) in common carp, *Cyprinus carpio* subjected to a rapid sub-lethal (1 ppm) malathion change from 0.1 ppm, at the rate of 0.1 ppm/h. Each point is a mean of 10 individual measurements.

Repeating the above experiment introducing malathion pollution changes instead of temperature changes, on common

carp (*cyprinus carpio*), using 0_2 consumption and RBC count as indices, results as shown in Figure 3 and 4 are obtained. With slow rise in malathion (0.1 ppm/2 days) 0_2 consumption and RBC count increased steadily to control levels. With rapid increase in malathion (0.1 ppm/h) the increase in 0_2 consumption and RBC count did not reach the control levels.

It substantiated earlier field work[6] of behavioural adaptation of fish to malathion sprayed aerially to control mosquito vectors. The respiratory behaviour (operacular activity), the food intake behaviour (through analysis of the gut contents), behaviour in the movement of the body and in growth patterns are found to be entirely different and distinct during the processes of "pollutional stress" and "pollutional-adapation". In the fishes which are subjected to a slow malathion change (0.1 ppm/2 days) resulting in the process of adaptation the behavioural patterns in the said parameters are normal in the sense that the time taken for 10 opercular movements (for respiratory behaviour) is 6.35 seconds; the food intake capacity is 70.5%; growth took place at the rate of 60%, and movements of the body of the fish without jerkings are observed whereas in the fishes which are subjected to quick malathion change (0.1 ppm/h) resulting in "stress", the behavioural patterns in the said parameters are abnormal. The time taken for 10 opercular movements (for respiratory behaviour) is 2.20 seconds (70% in the respiratory behaviour); the food intake capacity is decreased to 34.4%; growth rate is retarded to 12% and the fish exhibited hyperexcitability and tremors and jerkings of the whole body.

Thus environmental stress is different from environmental adaptation. "Stress" is a physiological load acting upon an animal and the factors causing the stress are termed stressors. "Adaptation" is a slow process of compensation without physiological load. When the animals are under stress, nucleotides, 0_2 consmption, RBC count etc are different

from control levels whereas "adapted" animals evidence normal values.

Acknowledgements

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Studies in Animal Behaviour (Ed. Rao & Shetty) Suppl. Bulletin ESI III :153-162 (1984)

Histophysiology and Hormonal Control of the Specialized Eccrine Sweat Glands of the Male Indian Palm Squirrel, Funambulus Palmarum

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Secretions from specialized skin glands are the major source of chemical communication in mammals. Specialized cutaneous glands have been reported from most of the mammalian orders[1]. Specialization may involve the size of the gland as happens in the sebaceous glands or accumulation of large numbers in a specific area of the skin. In the case of eccrine sweat glands, specialization has occurred by the aggregation of large numbers of glands in a specific area of the skin. Although specialized eccrine sweat glands have been reported from the foot pads of the microtine and murine rodents[2], there has been very little information with regard to these in the seiurid rodents. Hence the present study has been undertaken in order to elaborate our concepts regarding the histophysiology and hormonal control of specialized eccrine sweat glands of the foot pads of the Indian palm squirrel, *Funambulus palmarum*.

Materials and Methods

Palm squirrels were trapped alive using box type traps and brought to the laboratory. Males were weighed and only healthy adult animals weighing above 120 gms, were selected

for the study. Animals were housed in standard wire mesh cages (45 cms x 25 cms x 26 cms. size), one in each cage. Shredded news-print and husk were provided for bedding and empty cans were placed inside the cage as nesting place. In the absence of experimental manipulation, normal light conditions and temperature between 20°C and 30°C prevailed in the laboratory. The cages were cleaned at regular intervals.

Food and water were provided *ad libitum*. For histological and histochemical studies, animals were sacrificed by over etherization, samples of skin from the regions to be examined were removed, processed and sectioned for microscopic examination. Paraffin sections, 5 μm thick of the tissue fixed in aqueous Bouin were stained in Ehrlich's haematoxylin and eosin and mounted in DPX for histological observations. Sections from the adjacent region served as the control.

Histochemical studies were conducted by employing Sudan Black B for total lipids, Sudan III and IV for neutral lipids, Mercury bromophenol blue for proteins, Periodic acid Schiff's reagent for carbohydrates and Best's carmine for glycogen. Histochemical techniques were deployed in strict conformity with the procedures cited by Pearse[3]. For the study of lipids, fresh frozen tissues were sectioned in the model CTD International Cryostat at-20°C. 7 μm sections were stained with Sudan Black B and Sudan III and IV and were mounted in glycerine jelly. As for proteins, carbohydrates and glycogen, Carnoy fixed paraffin sections of 5 μm thickness were used.

Castration was effected under ether anaesthesia. Both the testes were removed after making two lateral incisions in the scrotal skin, one on either side. The stump left inside was tied with cotton thread, a little bit of sulpha powder sprinkled on the wound and the incisions were sewn up with cotton thread. Sham operation of the control animal was conducted exactly as explained above, excepting that testes were not removed. The animals were sacrificed after 8 weeks of castration. Skin

samples were processed for histological and histochemica examinations as detailed above.

Hormone administration was initiated four weeks after castration. Each castrated experimental animal received 2 mgs of Testosterone propionate diluted in olive oil per day for four weeks continuously, injected intramuscularly in the thigh muscles under ether anaesthesia. Control animal received olive oil without hormone in similar quantity, just as the experimental animal for the same duration. The animals were sacrificed on the succeeding day of the last injections and skin samples were processed for histophysiological studies as detailed above. The effects of castration and hormone administration on specialized skin glands were noted by comparing the changes in the histological aspects of the glandular tissues of the control animals and the castrated experimental forms.

A total of 17 animals were grouped into three as given below.

Group	No. of Experimental animals	Type of study	control animals	Total
I	5 Control	Histophysiology of the normal skin glands.	Adjacent skin samples served as control.	5
II	5 Castrated	Histophysiology of the skin glands of the castrated.	1 sham operated animal.	6
III	5 Hormone administered	Histophysiology of the skin glands of the hormone administered.	1 Castrated animal receiving pure olive oil injections.	6

Statistical analysis of the data on histomorphological features was done by employing Students' 't' test.

Results

Tabular coiled glands are present in the hypodermis of the elevated pads of both palmar and plantar regions. Each gland opens out on the surface directly and are not associated with hair follicles. These glands, present in large numbers in each foot pad, have been identified as the specialized eccrine sweat glands. Three portions can be discerned in each eccrine sweat gland : an epidermal, an upper dermal and a hypodermal part. The first two parts are straight whereas the third part is coiled. The third part is actually the glandular secretory part. The tubule of the eccrine sweat gland starts at the stratum granulosum, whereas the flat layer of epithelial cells invaginate to form the lining of the duct. In the upper dermis, the duct is lined with two layers of malpighian cells in addition to the inner lining of flat epithelial cells. In the deeper dermis, these two layers get narrowed down to one. The tubule in these parts is straight. In the hypodermis, where the tubule becomes the secretory part, it coils a little and subsequently enlarges. The secretory part is coiled and as many as 10 folds have been noticed in this region. The walls of the tubule have the glandular cells arranged in a single layer, with an outer envelope of myoepithelial cells. The cells, cuboid or oval in shape rest on a basement membrane.

Two different types of cells have been distinguished; a clear cell which is slightly bigger in size with compact nuclei which takes up very little stain and a dark cell, slightly smaller with vesicular nuclei containing two to three conspicuous nucleoli which stains dark with dense eosinophilic cytoplasm

Regarding morphometric details, the eccrine sweat glands of the plantar region and those of the palmar region differ in the dermal exit tubule, overall diameter of the glandular secretory tubule, diameter of the wall of the glandular secretory tubule and the width of the nuclei in the secretory tubule. As for the other details, there is no significant difference at all.

Eccrine sweat glands exhibit a positive response to Sudan Black B revealing the lipid content of the glands. The dermal exit tubules also get stained. The response to Sudan III and IV is rather low indicating the minimal quantity of neutral fats present in the glands. However, an intense reaction is shown to Mercury bromophenol blue with a deep blue colour and the secretory cells in higher magnification exhibit intensity variations. The dark cells which developed higher intensity of colour indicated increased quanta of protein as compared to the light cells.

Positive response is shown by the eccrine sweat glands to PAS. The peripheral regions are more intensely stained than the glandular cells, suggesting that carbohydrates are generally present in the eccrine sweat glands and that the carbohydrates are relatively localized in the basement membrane and myoepithelial cells.

On being stained with Best's Carmine, only alternate cells take up the orange red colour indicating the selective presence of glycogen therein. It can be inferred from the size, that it is the clear cell which contains glycogen and gets stained with the Best's Carmine.

The disintegration of coiled tubules has been noticed in castrated animals, 8 weeks after castration. This disintegration is more pronounced in the deeper layers of the dermis. In the process of degeneration, it is the distal end of the tubule which is effected initially. The nuclei tends to become pyknotic, the distinction between the clear and dark cells is lost and the cells break up. Further, histological data clearly indicate that the glands have become hypotrophied on castration. Subsequent to hormone administration the glands become reactivated and this is well substantiated by the histological data (Figs. 1, 2, 3 and 4).

The eccrine sweat glands of the fore foot and hind foot exhibit similar histochemical traits. They do not exhibit any

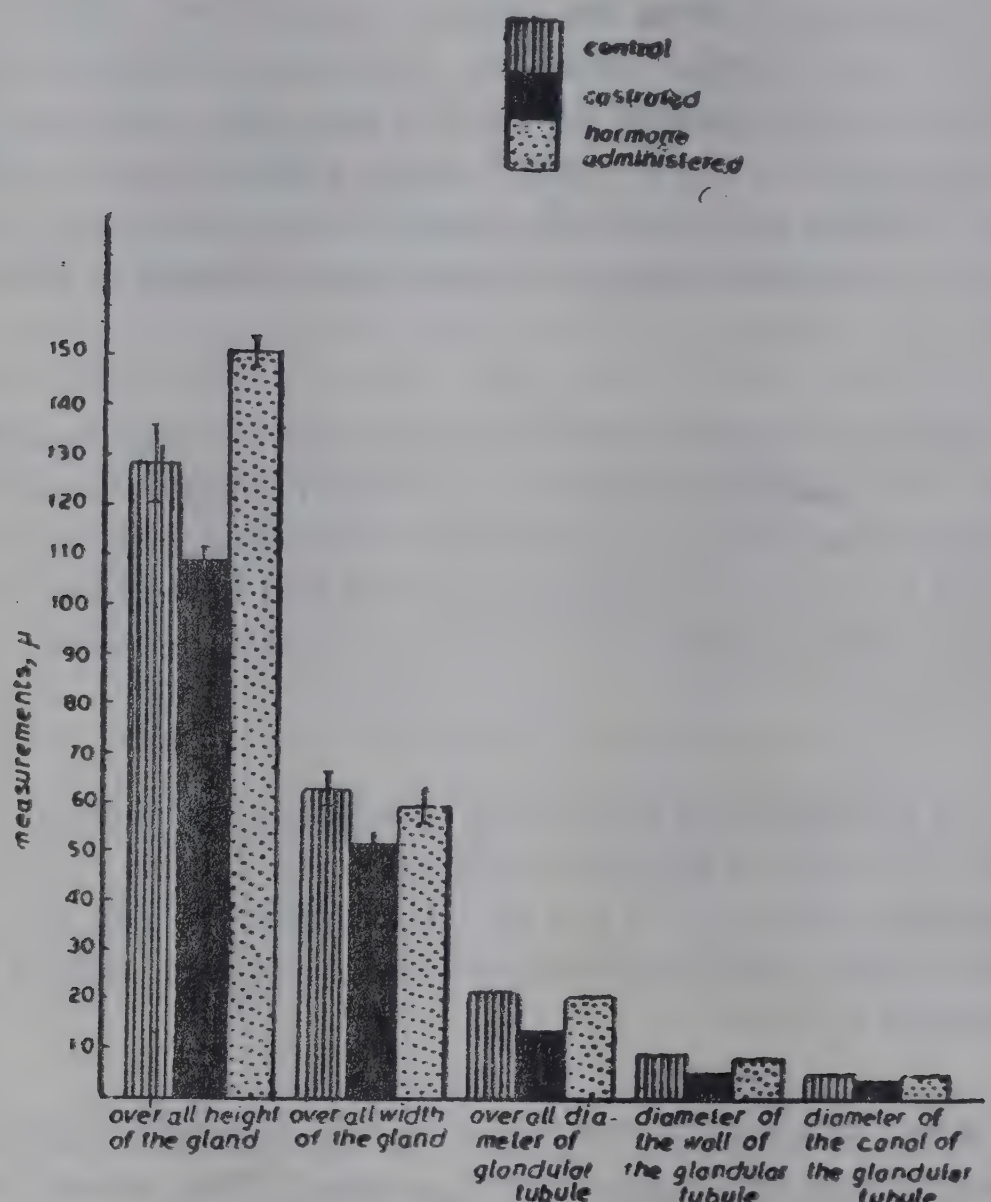

FIG 1 EFFECT OF CASTRATION AND SEX HORMONE ADMINISTRATION ON THE SECRETORY PORTION OF PALMAR ECCRINE SWEAT GLANDS

variations regarding their response to castration and hormone administration.

Discussion

The glands of the palmar and plantar foot pads are the modified eccrine sweat glands. The gland has a coiled secretory part in the hypodermis, a dermal exit tubule, straight with

two layers of cells in the walls, and a straight epidermal part where by it voids at the surface. In the glandular regions the

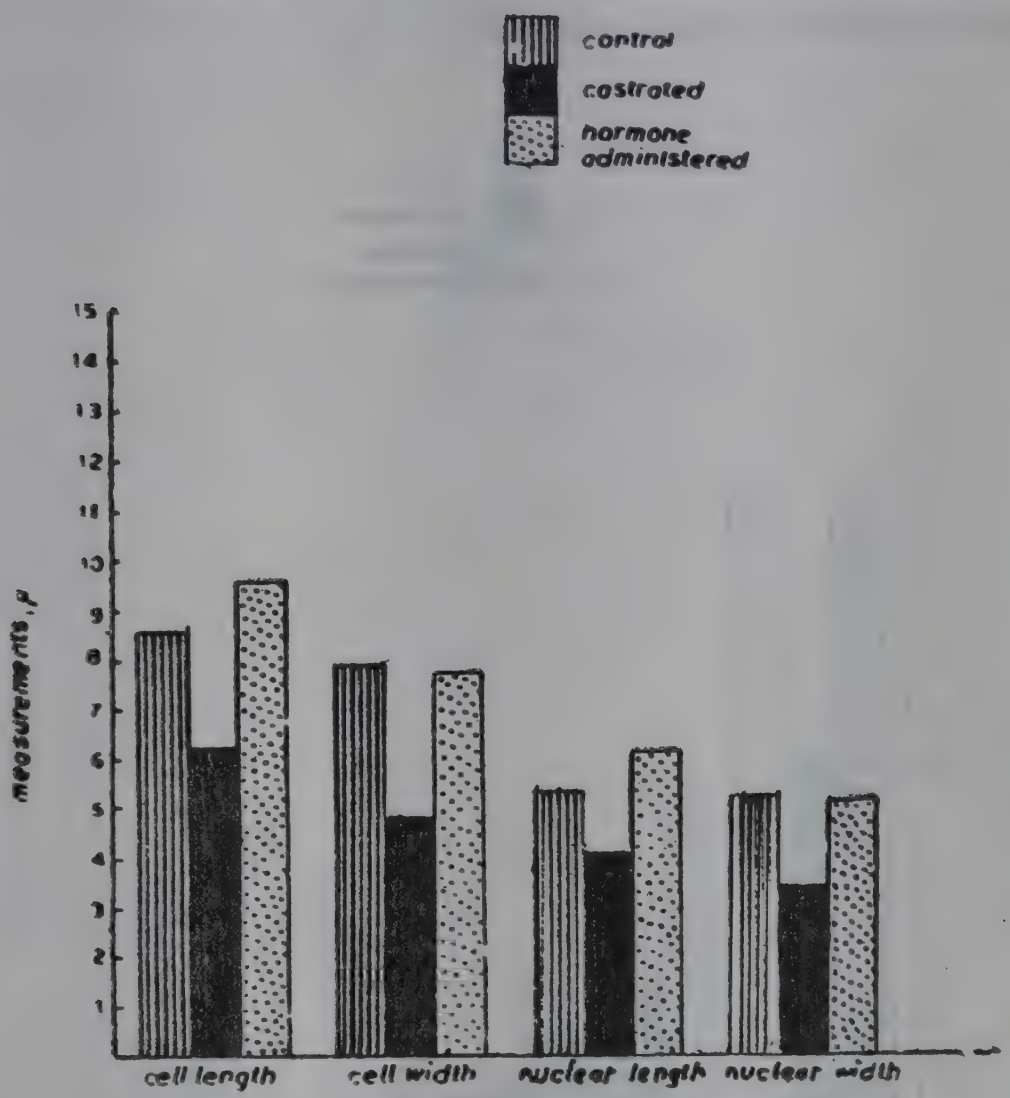

FIG 2 EFFECT OF CASTRATION AND SEX HORMONE ADMINISTRATION ON THE CELLULAR AND NUCLEAR MEASUREMENTS OF THE SECRETORY TUBULE OF PALMAR ECCRINE SWEAT GLANDS

secretory epithelium has two different types of cells, a clear cell and dark cell. In all these respects, these glands compare favourably with similar glands reported in other mammals [2,4,5].

Histochemically the glands are lipoid and proteinaceous. Proteins are present in the dark cells in much larger quantity than in the clear cells. Carbohydrates are present, mucopoly-saccharides being localized in tubule's boundaries like the basement membrane, myoepithelial cells and also in the dark

cells. Glycogen occurs in the clear cells. The data on histochemical traits of the eccrine sweat glands in the squirrel, *Funambulus palmarum* corroborate the observations made by other workers in other mammals.[2,4,5,6,7]

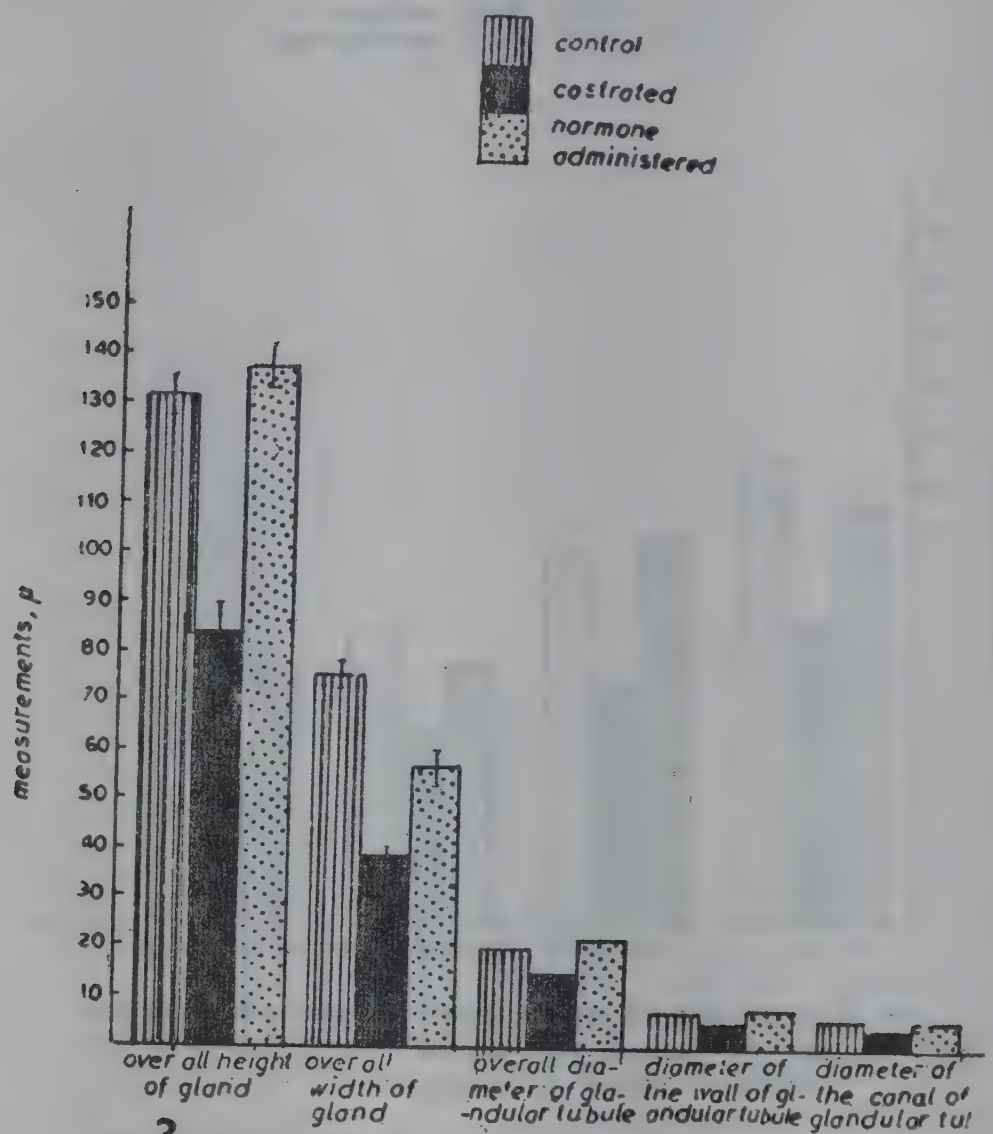

FIG. 3 EFFECT OF CASTRATION AND SEX HORMONE ADMINISTRATION ON THE SECRETORY PORTION OF THE PLANTAR ECCRINE SWEATGLANDS

The eccrine sweat glands of the palmar and plantar regions revealed hypotrophy on castration and reactivation on hormone administration, in the squirrel, *Funambulus palmarum*. The degeneration process was more rapid in the deeper layers, setting in initially at the distal portion of the tubule and the distinction between the clear and dark cells was lost. Compa-

rable data from other mammals are totally absent in the case of eccrine sweat glands. The only evidence on the positive effect of sex hormone on these glands has been based on the reports of hypertrophying of these glands by local administration of testosterone in rats [8,9].

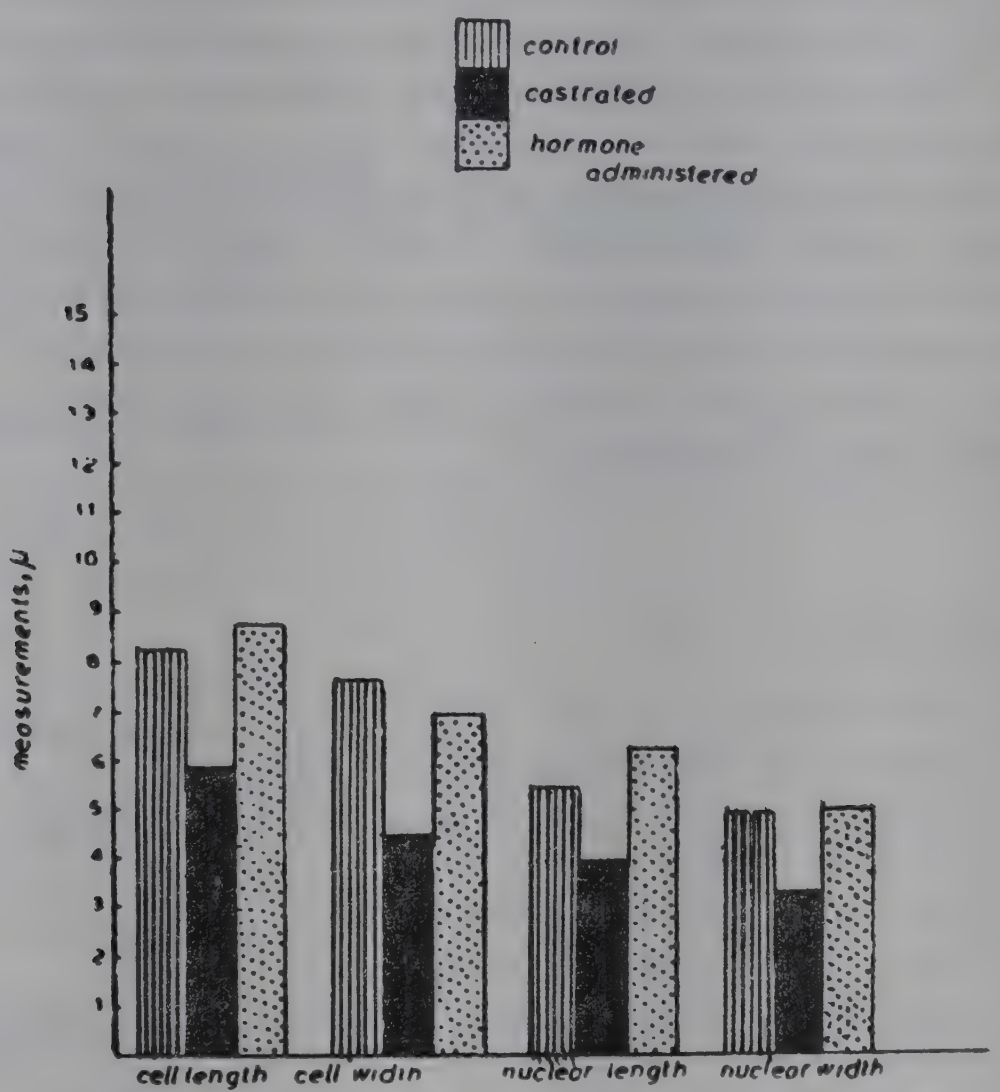

FIG 4 EFFECT OF CASTRATION AND SEX HORMONE ADMINISTRATION ON THE CELLULAR AND NUCLEAR MEASUREMENTS OF THE SECRETORY TUBULE OF PLANTAR ECCRINE SWEAT GLANDS

The eccrine sweat glands have been shown to be mainly thermoregulatory in function [10]. However Adams [11] has pointed out that the specialized eccrine sweat glands do produce odours of biological significance. In the plantar of the mouse foot, eccrine sweat glands have been shown to secrete an individua|

recognition scent and the fact that the palmar and plantar surfaces of human beings secrete in stressful or emotional conditions, and in females secrete steroids[7], strongly indicate that these glands are also of pheromonal significance.

Regarding the Squirrel, *Funambulus palmarum* these glands have been shown to be lipid secreting and are influenced by the sex hormones. These data also suggest that these glands are behaviourally significant. Our observations in the field have revealed that the specialized eccrine sweat glands are deployed in communication with regard to individual identification of the conspecifics. Further, bioassay experiments conducted in our laboratory with the secretions from the plantar and palmar surfaces have confirmed that the specialized eccrine sweat glands have a specific role in individual identification during social interactions.

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Dimorphic Sexual Behaviour of Gonadectomised Male Dog in its Natural Habitat

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Sexual behaviour in the male is dependent on gonadal androgens and sexual activity declines in adult males following pre-puberal, puberal or post-puberal gonadectomy [1,2,3]. Beach studied the coital behaviour of dogs and has for purposes of analysis divided their complete coital pattern into four arbitrary and usually successive phases [4]: (1) Testing and Stimulating which tends to occur prior to the males initiation of mounting responses and includes a variety of copulatory repertoire like approach, paw, prance and investigation (licking the vulva, etc). (2) Mounting and Thrusting where the male mounts the bitch and achieves an insertion. (3) Intromission and Ejaculation beginning with the male achieving insertion, includes the coital lock and ends when the lock is broken. (4) Post-lock behaviour.

Beach has documented that castration at or around puberty leads to deterioration of Intromission and Ejaculation phase whereas Mounting and Thrusting phase of coital pattern is not much affected [4]. This may be true of the sexual behaviour patterns of gonadectomised male dogs in experimental situations where only the gonadectomised male is left with a bitch. What happens to a gonadectomised male during free living conditions in a sexually competitive society of dogs? Does

gonadectomy alter only sexual behaviour or does it affect the social behaviour and hierarchy of the male? Does dimorphism in sexual and social behaviour become manifest as a result of the hormonal imbalances resulting from gonadectomy [5], under free living situations? These are questions that are attempted to be answered by this study.

Materials and methods

A well nourished, domesticated male pup (*Canis familiaris*) was gonadectomised under anaesthesia before puberty (around 4 months of age). One year after pre–puberal gonadectomy, its behaviour patterns were observed closely and continuously during varying intervals of time over a total period of 18 months in a semi-urban area with large tracts of vacant land and open spaces. The steady population of other dogs in this field area consisted of 4 females and 10 males (total of 14 other dogs excluding the subject). The observational data consists of a survey of the general behaviour of the gonadectomised male dog (GXMD) as well as its social and other interactive behaviour with the rest of the dogs in the colony. Behaviour patterns were carefully studied during the period of estrus of 2 of the bitches in the colony through a total of three estrus cycles.

Results and Discussion

A critical analysis of observational data on the GXMD is categorised and discussed under (a) sexual behaviour (b) socio-sexual and sex-related bebaviour and (c) social behaviour.

Examination of gonadectomised male dog (GXMD) showed a well developed and well nourished animal. The only findings of interest were the total absence of a scrotal sac and an infantile penis. Retraction of the prepuce to expose the glans penis was not possible as in the case of a normal male.

(a) *Sexual behaviour*:

The GXMD appeared to be indifferent to the sex of the animals in the colony and did not show any interest in the female of it's species during the non-estrus phase of females. Only a mild degree of ill-sustained interest was noticed at the time of estrus of one of the bitches in contrast to keen interest and strong motivation for sexual contact with the estrus female evinced by all other males in the colony, irrespective of their social dominance status. Castrated male dogs are known to compare favourably with intact males with regard to the early (i.e. Mounting and Thrusting) phases of mating pattern whereas the later (i.e. Intromission and Ejaculatory) phases of behaviour are adversely affected[4]. But the GXMD was never seen attempting to mount or adopting thrusting postures on an estrus female, although one cannot be too certain as the GXMD was not under 24 hour surveillance. In an experimental set up, when only one male (castrated or intact) is presented with one female, the absence of deficiency in the early phase of coitus may be elicited; but in all likelihood, in its natural competitive set up, a gonadectomised male never gets a chance to exibit this capacity.

The bitch in estrus demonstrated typical preferential mating with the male[6] and in its behaviour towards males it ignored totally the existence of GXMD among the available males. None of the females in estrus evinced any interest or preference to the gonadectomised male.

The GXMD on the other hand showed greater preference to the males in the colony and 'solicited' their interest by many modes including presentation of his posterior to males; a behaviour pattern typical of the female.[6] There was an increased tendency on the part of the males unsuccessful in their attempts to obtain sexual contact with a bitch in estrus, even after attempts to mount in tandem on the female to show mounting and thrusting attitudes on the gonadectomised male. There is

no question of intromission or the achieving of a coital lock–to use Beach's argument "you-cannot–be–a–carpenter–without–a–hammer"; though a few of the aggressive males have achieved ejaculation after repeated thrusting on the GXMD. The GXMD not only showed no objection to this sexual display by other males but also showed a tendency to solicit such attention from males. The castrated male dog manifested female type of sexual behaviour during the estrus of one of the bitches in the field. The subject clearly demonstrated dimorphism in his sexual behaviour as a result of castration; and the overt expression of such female type of behaviour occured without resort to administration of oestrogens; although reversal of sexual behaviour to variable degrees has only been reported following the administration of heterotypical hormones to gonadectomised adults[7].

(b) *Socio–sexual behaviour:*

Whether a female is in estrus or not, normally all males show an interest in females which is manifested by following it and by marking the exact spot where the female urinates and other males try to urinate on the same spot as the female, one after the other in their peck order. The gonadectomised subject showed very casual interest in a female (particularly during the non-estrus phase) as though it were just another dog; showed no inclination to follow it and no tendency to mark the spot with its own urine. During the estrus in a female the normal dogs showed excessive interest in marking; they even licked the urine of the female and if possible the external genitalia of the female. It is only if a female is in estrus that the GXMD showed any tendency to follow it casually, and to mark the spot with its own urine. Only during this period the gonadectomised male also showed a tendency to scratch after micturition or defecation; a behaviour pattern commonly seen in aggressive males. It would appear that the gonadectomised male manifested a typical male response, though at a very low key, when a female was in

estrus, but otherwise did not bother to exibit even traces of its normal male socio-sexual behaviour.

The urinary posture of the gonadectomised male showed the male type leg elevation during micturition[8]. This is in further support of the work of Berg[8], Martins and Valle[9] and that of Beach[4], that gonadal androgens are not essential for the appearance of the male urinary posture in castrated dogs.

(c) *Social behaviour*:

Even the classical social behaviour patterns of the male dog seem to be affected by gonadectomy. Scott and Fuller[10] studied the developmental history of puppies in the laboratory in great detail and divided it into regular periods based on important changes in social relationships. These periods which are variable, are roughly timed as follows: (1) Neonatal period-from birth until eyes open at about 10 days. (2) Transition period-from the time the eyes open until the animal first responds to sound at about 20 days of age. (3) Socialization period-which lasts until weaning at 7 to 10 weeks and (4) Juvenile period-from this time until the animal attains adulthood and is first capable of mating behaviour (anytime from 6 months to more than a year).

The gonadectomised male showed characteristics of this juvenile period i.e. excessive playfulness throughout the day, playful fighting, and intimate social contacts with all the dogs in the neighbourhood irrespective of the sex. It, in short behaved much like an overgrown pup and hence would appear to show behavioural fixation in the juvenile period of development. The agonistic behaviour patterns of the gonadectomised male are characterised by lack of adoption of dominant postures over other males and also peculiarly it rarely ever adopts an attitude of subordination to other dogs. Its entire social pattern seemed to be like that of a pup which does not normally enter into the social peck order or hierarachy in an animal society. Apparently

Comparison with Behaviour Patterns of Dogs (Canis familiaris)

Behaviour Patterns (According to Scott & Fuller[10])	Normal Dogs F = Field N = Nursery	Gonadectomised male
I. Investigative Behaviour		
Walking or running with nose to the ground	F, N	+/-
Head raised, ears erect, (listening, looking)	F, N	+
Sniffing nose or face	F, N	+
Sniffing anal and/or genital region	F, N	-/±/D
Nosing and sniffing urine or feaces	F, N	D
II. Et-Epimeletic Behaviour	N	+
Touching with paws	N	++
III. Allelomimetic Behaviour	F, N	+
IV. Eliminative Behaviour		
Micturating with hind leg raised	F, N	+
Scratching ground with all four feet after defecation	F, N	+

V. Agonistic Behaviour		
A) **Fighting and Predation**		
Snarling (showing teeth)	F, N	−
Growling	F, N	−
Barking	F, N	+
Playful fighting	N	+ + +
B) **Defense and Escape Reactions**		
Yelping and showing teeth	F, N	−
Tail between legs	F, N	−
C) **Attitudes of Dominance**	F, N	−
D) **Attitudes of subordination**	F, N	−
E) Miscellaneous: Hair raising	F, N	+
VI. Sexual Behaviour		
Male		
Running with female, Licking female genitalia	F	D
Mounting, clasping, pelvic thrusts, copulatory tie	F	−
Female		
Soliciting	F	D
Standing for male	F	D

+ = present
− = absent
D = dimorphic
F = field
N = nursery

gonadectomy considerably influences its social behaviour and hence its social status thus leading to lack of participation in the social hierarchial organisation. Comparison of behaviour patterns of dogs with that of the gonadectomised male subject based on Scott's classification [10] is summarized in the Table.

In conclusion it may be stated that the field study of behaviour patterns of a gonadectomised male dog (*Canis familiaris*) in its natural habitat showed dimorphic patterns particularly in its sexual and socio–sexual behaviour; where dimorphic behaviour would well be defined as any observable response that is displayed more frequently, more readily and more intensely by one sex than by the other[5]. It also, at the same time showed changes in its social behaviour and lack of participation in the social hierarchial organisation. Alterations reported in any behaviour pattern following changes in the hormonal status of the animal pre or post natally, pre or post puberally under experimental situations need to be always reassessed and clarified under field conditions, in the animals own natural habitat.

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Effect of Two Insecticides, Phosalone & Sevin on the Survival & Behaviour of the Fiddler Crab Uca lactea annulipes

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It is well known that insecticides at sublethal concentrations alter the behaviour of fiddler crabs (eg., escape, righting and burrowing) significantly.[8,13] George *et al.*[6] reported that spraying of BHC modified the escape response of the fiddler crab *Uca puanax*. Similar changes in the escape behaviour were observed in *U. puanax* fed with organic detritus containing 10 ppm DDT[10]. Klein and Lincer[8] observed that in *U. pugilator* fed with Dieldrin treated tetramine flakes caused marked behavioural changes like runaway, righting and aquarium behaviour within 24 h. The work of Ward and Busch[13] disclosed by 24 h bioassay that exposure of *U. pugnax* to 4.31 ppm concentration of Temafos (organophosphorus) resulted in death or impairment of the escape behaviour in 50% crabs tested. Plumby *et al.*[11] observed that Atrasine, a photosynthesis inhibitor either killed or eliminated the escape response (considered to be analagous to death) in *U. pugnax*. There is no information on the effect of insecticides on behavioural changes in the Indian species *Uca lactea annulipes*. Though it is known that phosalone (organophosphorus) and sevin (carbamate) inhibit acetylcholinesterase activity in arthropods resulting in the behaviour changes (escape, righting and burrowing).

Methods and Materials

Male crabs of size ranging from 9 to 15 mm were collected from rhe intertıdal region opposite to Marine Biological Station Just after the receding tide and kept in plastic containers for acclimatisation. The acclimation and testing were carried out following the method of APHA[1]. The environmental parameters like salinity, oxygen, pH and temperature were also determined (S% – 31.6; pH - 7.6; oxygen – 4.32 mg/l and temperature – 29°C).

24 h acute toxicity was determined following the method of Litchfield and Wilcoxon [9]. After a week of acclimatisation, crabs were randomly selected and assigned in groups of ten to small aquaria (30 cm x 50 cm x 30 cm fibre glass tanks) to determine the 24 h acute toxicity. Each tank was randomly assigned to a concentration ranging from 0.1 to 9.6 ppm. Two controls were simultaneously maitained with and without acetone. A total of 275 crabs were tested.

Escape, righting and burrowing behaviours were chosen to study the behavioural responses as outlined by Klein & Lincer[8] and Ward & Busch[13] with slight modifications. The former author used a finger as a threatening agent and the latter subjected the crabs to a whillet from behind. In the present study the crab was subjected to a bird model aerially and a sandy substratum was provided to give a condition existing in the natural environment. An average time of 10 sec was assigned to study the escape activity as the normal crab crosses the line within 10 sec. The 24 h acute toxicity test serves only as an index to asses the efective mortality assuming the aberrant behaviour of the crab such as *Uca lactea annulipes* when exposed to pesticide will have a lethal consequence in the field.

Results and Discussions

24 h acute toxicity bioassay revealed that there is a significant increase in the percentage of mortality with the increasing concentration of phosalone and sevin. The 24 h LC 50 values of phosalone and sevin are given in Table 1. The 24 h acute toxicitv test indicates that of the two insecticides used, phosalone was more toxic than sevin.

Table 1. 24 LC 50 and EC 50 (ppm) and associated statistical parameters for mortality and mortality plus disappearance of escape reaction of *Uca lactea annulepis* exposed to various concentrations of phosalone and sevin.

Pesticide	LC 50	95% confidence limit	Slope 'S'
Phosalone	1.65	1.08 – 2.46	1.51
Sevin	1.45	1.09 - 1.93	1.49

Pesticide	EC 50	95% confidence limit	Slope 'S'
Phosalone	1.00	0.67 – 1 50	1.66
Sevin	0.88	0.59 – 1.32	1.65

Control crabs are very agile which increases the survival value of the animal when a predator approaches and the crab is far away from the burrow. Percentage of escape behaviour decreased with increasing concentration of phosalone and sevin. Crabs exposed to 0.1 ppm of phosalone appeared normal when threatened. But crabs exposed to a concentration of 0.3 ppm to 1.5 ppm of phosalone showed a progressive decrease in the escape behaviour. Crabs treated with 0.3 ppm to 0.6 ppm of phosalone, though not agile as compared to the control crabs, which normally crosses the lines 30 cm apart in 10 sec

succeeded in crossing the line at 12th sec with raising of major chelae towards the bird model. This probably might be essential for the survival of the animal when a predator threatens. Exposed crabs at 0.6 to 1 5 ppm concentration of phosalone resulted in uncoordinated waving of chelae, inability to escape, moving awkwardly, erratically and slowly over a short distance and then moving to a corner showing no reaction. Crabs exposed to a concentration of 2.0 ppm and 2.5 ppm of phosalone revealed that the crabs were reluctant to move. They ware seen just throwing out chelae asynchronously at the threatening object and often falling back while doing so and also by an eschew of foam from the mouth. Similar obsevations were reported for the fiddler crab *U. pugnax* exposed to 1.5 to 15.0 ppm of Temefos [13]. Klein and Lincer [8] from a long term study reported that the fiddler crab *U. pugilator* also showed similar results. Odum *et al.*[10] observed a similar behavioural pattern when crabs were fed with sediments having 10 ppm of DDT.

Crabs treated with various sublethal concentrations of sevin seemed to be compartively more alert and exhibited a general uncoordinated behaviour with appearance of foam in the mouth and a slight overall slowing down of movement.

The effective concentration (EC 50) values at the end of 24 h acute toxicity test were 1.0 ppm (phosalone) and 0.88 ppm (sevin). The effective concentration was determined in terms of percentage mortality and escape behaviour 24 h EC 50 indicated that phosalone was more effective on the escape behaviour than sevin. Butler [3,4], Stewart *et al.*[12] and Earnest[5] found concentrations (ppb) causing acute effects (loss of equilibrium, paralysis or death in 24, 48, 96 h of exposure) to be 1000 for stone crab, 600 for Dungenes crab (*Cancer magister*) and 550 for the blue crab (*Caliinectes sanidus*). Buchanan *et al.*[2] found that the 24 h EC 50 (0.62 mg/l) resulted in death or paralysis of the later stages of juvenile crab. Ward and Busch[13] reported that Temefos at a concentration of 4.31 ppm caused death or impairment in the escape behaviour.

Marked behavioural changes in the crabs ware seen when exposed to phosalone. This is most probably due to the inhibition of acetylcholinesterase thereby obstructing the neural transmission [13]. Thus the EC 50 serves as a quantitative measure of sublethal sensitivity to the toxicant.

Righting response is another index assisting escape behaviour. Crabs normally right at times when inverted by accidental means. At the end of 24 h acute toxicity, crabs subjected to righting showed decrease in righting in relation to the concentration. Unlike treated crabs, the control crabs showed no change in the righting behaviour as they quickly righted in seconds when kept in the inverted position (Fig. 1).

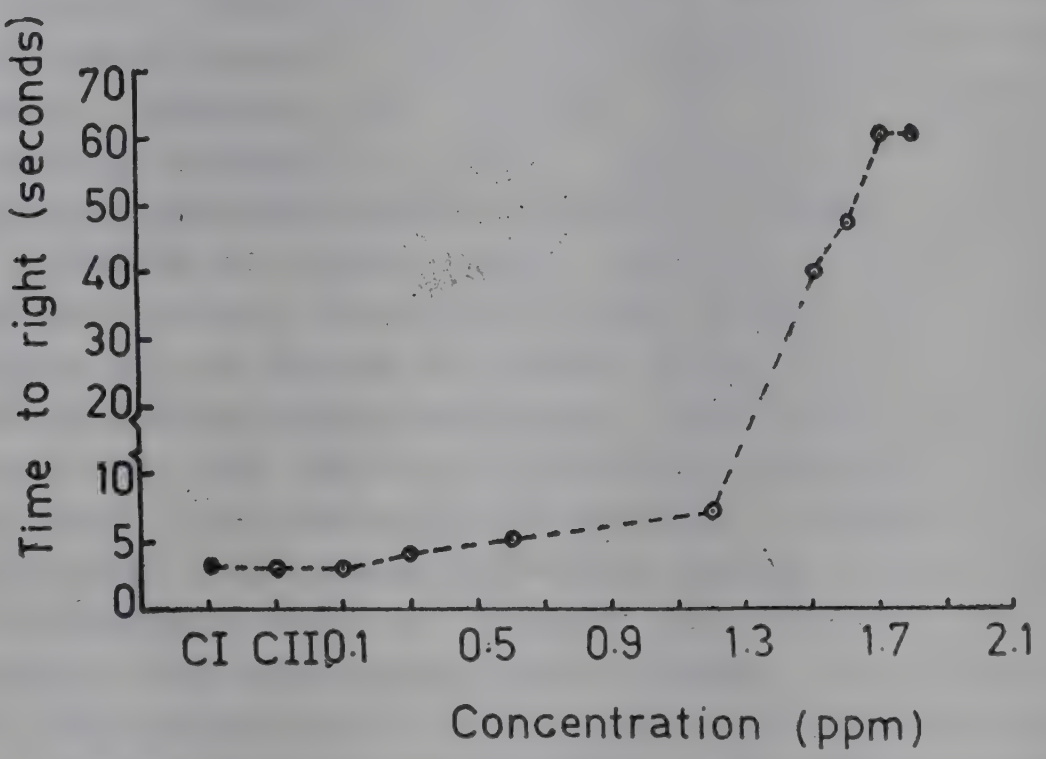

Fig. 1 : Righting response time of fiddler crabs as affected by various sublethal concentrations of phosalone

Crabs exposed to a concentration of 0.1 to 1.2 ppm of phosalone revealed only a lesser degree of delay in the righting response in comparison with the control but disclosed a stress which would result in possible predation by birds in the natural condition. Crabs treated with phosalone of concentrations 1.5 ppm and 1.8 ppm were measurably slow in righting.

Crabs exposed to a sublethal concentration of 1.5 ppm and 1.6 ppm of phosalone succeeded in righting at 40th and 47th sec whereas crabs exposed at concentrations of 1.7 ppm and above failed to exhibit righting response even after a maximum time of 60 sec which may limit its escape response from the predators. Crabs exhibited a great difficulty in righting with the major chelae and the ambulatories stretched and it squirmed to right. Klein and Lincer [8] reported a parallel progressive increase in the impairment of righting behaviour with increase in the concentration of Dieldrin (50, 10, 1 and 0.1 ppm) and also increase in the number of days.

Burrowing is the instinct of *Uca* to avoid predators. Control crabs were very agile and immediately burrowed or entered into the premade burrows when threatened suddenly by a predator. Crabs after treatment with pesticides revealed alterations in this response. A clear cut decrease in burrowing response or escape into premade burrow is seen with increasing concentration of pesticide. Crabs exposed to phosalone of concentration ranging from 0.1 to 0.6 ppm indicated that 80% of the crabs did neither burrow nor escape into the burrow when subjected to threat. Instead they tried to run with frequent pauses followed by throwing out the chelae. But crabs treated at a concentration 1.2 ppm of phosalone and above totally lost their burrowing activity and tried to escape when threatened. At times they were seen throwing the chelae asynchronously. Klein and Lincer [8] reported similar responses for crabs exposed to Dieldrin treated tetramine flakes at a concentration of 50, 10, 1 and 0.1 ppm. The burrowing and righting response are restricted only to phosalene. Sevin, though toxic in nature did not produce reproducible results. This perhaps was due to the fact that carbamate compounds were less soluble in water and highly unstable [7].

To evaluate a realistic effect of a pollutant on *Uca* it is necessary to know the impact of the tidal rhythms and environmental fluctuation on the behaviour along with the sublethal

effects of the pollutants on the behaviour of this species whose survival depends on rapid and finely tuned responses of the perceptual motor system.

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The Endangered Wildlife of India and their Conservation

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India has an excellent array of wildlife, though unfortunately, a vast majority of these are now on the verge of extinction. As compared to some of the other regions such as East Africa, North America, our country is slower in acquiring the requisite expertise and advanced training in wildlife conservation. The paucity of competent persons is the main reason for diverse problems possibly involved in wild life preservation.

In response to the evolutionary process, certain species become extinct and certain others evolve with the time. Further, population of any species may dwindle down after attaining a maximum growth rate for some time due to diverse reasons. Fluctuation of the population of a particular species would also affect the populations of other species co-habiting the same area. However, as compared to the rapid rate of extermination of certain species of animals by the natural extinction and population fluctuations, the latter is very slow. Further, The fact that species which are becoming extinct rapidly happen to be those with costly horns, beautiful fur or feathers, reveals the human involvement in extinction. Apart from the direct decimation of animals, there are other indirect causes. The habitat destruction for agriculture, for multipurpose projects, have facilitated the congregation of wildlife, causing 'population

explosion' and culminating in the death of many members of the species. It is estimated that about 1,000 species of animals and 20,000 species of plants are threatened with extinction in the world. At present one species of animal per year faces extinction which is 10 times greater than the comparable figures during the period 1600 to 1950 which is really alarming The present rate of threat to many animal and plant species is quite unnatural and is mainly due to the unscientific and illegal activities of human beings with a view to reap immediate benefits without any consideration for long-term benefits and scientific assessments of facts. In India, Asiatic lion, tiger, rhinoceros, elephant, many antelopes, and primates in addition to many species of reptiles and birds, are threatened with extinction.

Endangered Mammals of India

At present, we have about 350 species of wild mammals in different forests of India. Of these, 81 are threatened with extinction. Although the conditions are more or less similar in different parts of the world, the rate of destruction of natural forests and the subsequent problems of extermination of animal species are at a higher rate in developing countries because of socio-economic conditions. Among 19 species of primates in India of which 12 are facing problems in maintenance of their population. This include the slender loris (*Loris tardigradus*) of South India and the slow loris (*Nycticebus coucang*) of North eastern regions. The lion tailed *macaque* (*Macaca silenus*) which is an endemic species restricted to certain areas of tropical evergreen forests of Western ghats has only about 800 individuals in total and that a second viable population of these has recently been reported from the Silent Valley forests of Kerala. The golden langur (*Presbytis geei*) of the interior forests of North eastern regions, especially the forests of Assam was not known to us until recently. The population of our only ape, Hoolook gibbon (*Hylobates hoolook*) of North

eastern India, and the Nilgiri langur (*Presbytis johni*) of South Indian forests have been dwindling fast as a result of large scale poaching for their flesh.

The two species of pholidota seen in the Indian sub continent are the Chinese pangolin, (*Manis pentadactyla*) which is restricted to the North eastern regions and the Indian Pangolin (*Manis crassicaudata*) found in the peninsular India. Both these species are theatened with extinction.

Of the 36 species of carnivores in India, 28 are facing extinction. Among the feilds, wolf (*Canis lupus*), jackal (*Canis cureus*), red fox (*vulpes vulpes*), Indian fox (*Vulpes bengalensis*), and wild dog (*Cuon alpinus*) were quite abundant in all the forests of India in the past. But the populations of these had been considerably dwindled. Among the bears, the Himalayan brown bear (*Ursus arctos*), Malayan sub bear (*Helarctos malayanus*) and the sloth bear, (*Melursus ursinus*) are theatened with extinction as a result of the loss of their natural habitat. The red or lesser panda (*Ailurus fulgens*) which is also known as cat bear is greatly endangered. We have 14 species of mustelids in India of which Erminae, (*Mustela erminea*) which is restricted to the forests of Western Himalayas and the Ratel, (*Mellivora capensis*), although they had a wide range of habitat extending through the whole forest areas in India, are endangered. Among the Viverridae, the Malabar civet, (*Viverra megaspilla*) seen in the coastal areas of Malabar, the spotted linsang or tiger civet (*Prionodon pardicolor*) and Binturong (*Arctitis binturong*) which are restricted to the eastern Nepal to Arunachal Pradesh and among the Hyaena, the striped hyaena (*Hyaena hyaena*) have been observed to have considerably reduced in their population. Among 15 species of cats seen in different forest habitats in India, the population of tiger (*Panthera tigris*) is almost reduced to a meagre number of 1500 animals in the early years of the seventies. However, after the implementation of "Project Tiger" the population of

this magnificent animal is reported to have increased to about 2500 heads. The Panther (*Panthera pardus*) has a wide distribution in the Indian sub continent and still their number has been reduced mostly due to the poaching for their beautiful skin. The snow leopard (*Panthera unca*) which is restricted to the Himalayan peaks has also been threatened with extinction. The desert cat (*Felis silvestris*), Lynx (*Felis lynx*), Caracal (*Felis caracal*), Jungle cat (*Felis chaus*), Leopard cat (*Felis bengalensis*), Pallas cat (*Felis manuel*), Rusty spotted cat (*Felis rubiginosa*), Fishing cat (*Felis viverrine*), Golden cat (*Felis temmincki*), Marbled cat (*Felis marmorata*), and the clouded leopard (*Neofelis nebulosa*) are also threatened as a result of diverse human activities in their forest habitat. It is disheartening to note that the Indian cheetah or hunting leopard (*Acinonyx jubatus*) which enjoyed a wide distribution in almost all the forest regions and was in plenty till the end of the 1940's was last sighted in 1952 in some parts of the forests now under the Tamil Nadu state. Since they could not be sighted in the natural forests afterwards, it is believed that this species is already extinct. They were hunted for the valuable skin which had a prominent role in the international skin trade.

Although the Dugong (*Dugong dugong*) was seen in sufficient numbers in the Gulf of Kutch, Gulf of Mannar, in the coastal areas of Malabar and in the Andaman Nicobar Islands, it has become very difficult to locate them now in any of these forests. The order proboscidae has only one species in India, the Indian Elephant (*Elephas maximus*). The males of this species (*tusker*) have been hunted for tusks. Further, the habitat destruction also resulted in the reduction in availability of food, and their population has been dwindling fast.

Among the Perissodactyla, the great Indian one horned Rhinoceros (*Rhinoceros unicornis*) had also enjoyed a golden era in the first half of this century in the Gangetic grasslands. However, today their number is considerably reduced to about

1,000 animals and the distribution is restricted to Northern Bengal and in some low lands of Assam. They have been hunted for their costly horns, which is supposed to have some aphrodisiac value. The smaller one horned rhinoceros (*Rhinoceros soundaicus*) and the Asiastic two horned rhinoceros (*Didernoceros sumatrensis*) have already become extinct. The distribution of the Indian wild ass, (*Asinus hemionus*) is restricted to the saline flats of the Rann of Kutch. The Tibetan wild ass (*Asinus kiang*) has been facing extinction and their population is restricted to some parts of Ladakh and Sikkim.

We have 32 species of deer in Indian forests of which 20 are threatened with extinction. The Andaman wild pig, (*Sus scrofa andamanensis*), The Nicobar wild pig (*Sus scrofa nicobaricus*) and the pigmy hog (*Sus salvanius*) are being hunted for their meat. The Kashmir stag or Hangul (*Cervus elaphas hanglu*) is now restricted to the Northern regions of the Kashmir valley and their total population is only about 300. The Swamp deer or Barasingha (*Cervus duvauceli*) is seen in some forests of Madhya Pradesh. They have a population of only about 2500 animals. The brow antlered deer (*Cervus eldi eldi*) is strictly restricted to the reed forests and grass lands of Manipur and in the Lottak lake area. This species was considered to be extinct. However, they were sighted again in the forests and because of protective measures their population has increased from 14 heads in 1975 to 30 in 1979. An equal number of them could also be seen in various Zoos in India. The Alpine musk deer (*Moschus sifanicus*) and forest musk deer (*Moschus chrysogaster*) have also been listed as endangered. They have been hunted for meat and musk. The population of Mouse deer, (*Tragulus meminna*) which is our lone representative of Tragulidae is also very low.

Among bovidae we have 21 species of animals of which 14 are listed as endangered. The black buck (*Antelope cervicapra*). Indian gazella (*Gazella dorcas bennetti*), Chiru or Tibetan

antelope (*Pantholops hodgsoni*), Tibetan Gazelle (*Porcapra picticaudata*), four horned antelope or Chowsinga (*Tetraceros quadricornis*), gaur (*Bos gaurus*), wild yak (*Bos crunniens*), wild buffalo (*Bubalus bubblis*), Urial or shapu (*Ovis orientalis*), Merkhor (*Capra falconeri*), Himalayan Ibex (*Capra Ibex*), Nilgai or great Tibetan sheep (*Ovis ammon hodgsoni*) serow (*Capricornis sumatraensis*), Takin (*Budorcas taxicolor*) and the Nilgiri tahr (*Hemitragus hylocrius*) are endangered, and urgent measures have to be undertaken for their protection.

Among the four species of hares seen in the Indian sub continent, the Assam hare or Hispid hare (*Caprolagus hispidus)* is endangered. They are now seen only in the Brahmaputra Valleys, Tarai and in Duars. Among 95 species of rodents 11 species of flying squirrels and two species of Mermots are threatened with extinction. The Travancore flying squirrel (*Petinomys fuscocapillus)* the common giant flying squirrel (*Petaurista petaurista)*, wooly flying squirrel *(Eupetaurus cinereus*) smaller Kashmir flying squirrel (*Bylopeters fimbriatus*). Hairy footed flying squirrel (*Belomys pearsoni)*, lesser giant flying squirrel (*Pataurista elegans*), the red and white flying squirrel (*Petaurista alborufus*), the Hodgsons's flying squirrel (*Pataurista meonificus*), the Gray's flying squirrel (*Petaurista nobilis*), the Particoloured flying squirrel (*Hylopetes abloni)* and the Phayer's flying squirrel (*Hylopetes Phayrei*) are the flying squirrels found threatened in India. The Himalayan marmots, (*Marmota boba*) and the longtailed marmots (*Marmota caudata*) are distributed in the Himalayan and Kashmir areas and in the Sikkim area. The population of these species of marmots are also reduced considerably and urgent measures should be envisaged for their effective protection.

The whole 25 species of cetacea represented in the Indian continent are threatened with extinction. This include the various species of whales and dolphins seen in our ocean and rivers.

India's vanishing birds

India has a rich avian fauna totalling nearly 1,200 species. Further, many migratory birds make seasonal visits to various parts of our country. Although, some of these beautiful creatures are harmful to our agriculture, they are equally good in controlling the noxious agricultural pests since most of them feed on insects. The sparrow extermination programme launched by Chinese in the sixties was therefore dispensed off swiftly. Although the eagle, owls, and crows, appear to be harmful are in fact, highly useful to humans as they feed on unwanted wastes. The following are a few species of birds which are facing extinction.

The great Indian Bustard (*Choriotis nigriceps*) is one of the typical examples of birds facing extermination due to poaching. They weigh 15-20 kg and live in small groups in certain parts of Rajasthan and Gujarat. They have been attracting shikkaris even from outside the country, who use trained falcons to locate and chase the bustards. The tragopaus of the Himalayas is yet another endangered group of birds in India. Of the four species of them in India, *Tragopau blythi* is the most endangered. To save this bird from extinction, the Kohima Zoo had started a breeding programme of these birds in 1973. They live in single, pairs or even in small family groups. Thc illegal snaring has made quails and partridges endangered and the Government of India has banned their killing in 1972. Prior to the imposing of this restriction, they were used as delicious dishes in posh hotels. The wide use of pesticides in agricultural practices also affected them adversely. The life of many duck species, for example, white winged wood duck (*Cairina scutalata*), the white eared duck (*Crossoptilon crossoptilon*), the pink headed duck (*Rhodonessa caryophyllacea*), etc. are also threatened. The Jerdon's courser (*Cursorius bitorquatus*) which was discovered in 1848 in small groups in Pennar Valley and Godavari basin is also endangered. Shooting and habitat

destruction are the major factors causing depletion of population of the Chir pheasant (*Cacrtus wallichi*) of Northern India. Even the once common gray jungle fowl is now becoming rather rare and if effective counter measures are not taken expeditiously, these birds will succumb to exploitation of human beings within a few years. The Indian National bird, Peacock (*Pavo cristatus*) is also one of the endangered birds of India. They are now safe only in some parts of Gujarat and Rajasthan where they are left undisturbed. In the southern states of India including Kerala, their population has come down due to poaching and habitat destruction. A few of them can be seen in the Bandipur and Parambikulam wildlife sanctuaries.

The life of the beautiful great Indian hornbill (*Buceros bicornis*) of the Western Ghats and eastern Himalayas is also threatened. However, a good population of them is still available in the Silent Valley forests, which is one of the comparatively less damaged forest habitats in South India. They are also seen in the Periyar Tiger Reserve and in the adjoining forest. Many of our birds of prey are also threatened with extinction. The Northern lizard hawk (*Aviceda jerdoni*), black crested hawk (*Aviceda leuphotes*), white bellied sea eagle (*Haliaeetus leucogaster*), the bearded vulture or Lammergeier (*Gypaetus barbatus*), Falcons (*Falco biarmicus*; *Falco chicquera*), etc. are some of the most endangered species among the birds. Further, the Blewitti owl or the forest spotted owlet (*Athene blewitti*) is considered to be extinct.

Vanishing reptiles of India

Many species of Indian reptiles are also on the verge or extinction. Crocodiles, Monitor lizard, python and a few species of snakes are in the list of the endangered species of the Red Data Book of the IUCN. They deserve special attention for their continued existence in India.

Crocodiles used to be killed in large numbers to sustain the skin trade, and export of their hard coat had been quite lucrative. The Estuarine crocodile which was once abundant all over India is now almost extinct and only a few of them are seen in Orissa. Their population is now being protected. The marsh crocodile or the mugger crocodile and the gharial are the other species whose lives are also threatened in India. In order to ensure conservation of crocodiles, various state governments had initiated several measures. The crocodile breeding and training centre in Hyderabad, and the Madras crocodile Bank associated with the Madras Snake Park are worth mentioning. In Kerala, the crocodile farming in Neyyar Dam is improving. Crocodiles are also seen in the Thunakadavu reservoir of the Parambikulam wildlife sanctuary.

Varanus is another species of reptile which is fast vanishing. They were killed for flesh which is said to have medicinal properties. The Python (*Python molurus*) is yet another species of reptile facing considerable problems for survival due to various human activities.

Conservation of India's Wildlife

Fire wood collection, Poaching, fishing, collection of minor forest produce, forest fire, encroachment for agricultural purposes, cattle grazing, forest plantations, taungia cultivation extraction of timber, and hydroelectric projects are identified as the major threats for the maintenance of forest habitat and the inhabiting wildlife in various parts of the country.

In India, research activities in the fields of wildlife biology and conservation of nature and wildlife are still in its infancy. It has been languishing for a long time due to paucity of adequate literature, dedicated personnel and funds. Our research organisations such as the Bombay Natural History Society and the Zoological society of India are mainly dealing with population ecology of a number of species. This gives

the fundamental idea about the status of the species concerned by which we group them in the list of 'extinct', 'endangered' and 'vulnerable', Further, a study on population ecology also benefits us to know about the population fluctuation and growth rate, in relation to the habitat alterations.

Recent strides of progress in ethological studies revealed the relevance of behavioural studies in the field of wildlife management and conservation. The behaviour of wild animals especially aspects concerned with habitat preferences, feeding, social, reproduction and communication signals play a salient role in the wildlife conservation in general and species preservation in particular. Hence in addition to the population studies, the behavioural biology of wild animals needs dedicated attention for providing a better insight into the wonderful world of wildlife for the effective conservation and development for reaping long term benefit. Further, legislation, formation of sanctuaries and national parks and popularisation of this subject are also quite essential for protection of a number of our vanishing species of fauna and flora. The utility of conservation of nature and its significance in the maintenance of human welfare should be incorporated in the teaching curricula of both school and college students. In addition to these, separate departments dealing with Wildlife biology should be started in our universities so as to create an active group of researchers in this fast developing field of biological sciences for a better conservation of our prestigious wildlife.